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Preparation for collection and monitoring of real-world fuel consumption data for light and heavy duty vehicles

Final report

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Executive summary

Introduction

This is the final report of the study for the European Commission entitled “*Preparation for collection and monitoring of real world fuel consumption data for light and heavy duty vehicles*”. This study aims to facilitate the elaboration and implementation of a systematic and periodic real-world fuel/energy consumption monitoring framework under the new Regulations setting CO₂ emission performance standards for new passenger cars and light commercial vehicles and for heavy-duty vehicles.

For new light-duty vehicles (LDV), the real-world fuel and/or energy consumption data will be collected using standardised on-board fuel and/or energy consumption monitoring devices (OBFCM devices), which are required from 2021 on by Commission Regulation (EU) 2018/1832 (amendment of Regulation 2017/1151 (WLTP)). Regulation (EU) 2019/631 setting CO₂ emission standards for new cars and vans empowers the Commission to adopt the data collection and reporting procedures in an implementing act.

For heavy-duty vehicles (HDV), similar provisions on the data collection, reporting and mandating the use of OBFCM devices are set out in Regulation (EU) 2019/1242 setting CO₂ emission standards for HDV, but the OBFCM standardisation legislation is still in preparation.

The primary focus of this study is in assessing the practicability of managing the data flows from the vehicles to the European Commission.

Options assessed

This study has reviewed literature and consulted stakeholders to assess the relative merits and drawbacks of possible options for monitoring and reporting the real-world fuel and energy consumption of light- and heavy-duty vehicles. The options considered are:

- A1. An obligation for vehicle manufacturers to enable the periodic transmission of real-world fuel and/or energy consumption of vehicles using the over the-air (OTA) connectivity of the vehicles. The vehicles would transmit the data to the manufacturers who would collate the data and report it to the European Commission or European Environment Agency (EEA).
- A2. An obligation for vehicle manufacturers to enable the periodic transmission of real-world fuel and/or energy consumption of vehicles using the over the-air (OTA) connectivity of the vehicles. The vehicles would transmit the data directly to the European Commission or EEA.
- B1. An EU-wide obligation for Member State national authorities to collect periodically the average real-world fuel and/or energy consumption of vehicles, as part of the periodic technical inspections (PTI), and report it to the European Commission or EEA.
- B2. A request from the Commission for national authorities to collect periodically the average real-world fuel and/or energy consumption of vehicles, as part of the PTI, and report it to the European Commission or EEA.
- C. Various regular "ad-hoc" fleet sampling approaches by the Commission or on behalf of the Commission. This includes the collection of data from vehicles during their first servicing (Option C1); utilising existing in-service conformity checks (Option C2); working with fleet managers (Option C3); and ad-hoc sampling of voluntary collection of data either OTA or through periodic technical inspection (PTIs) (Option C4).

Data protection considerations common to all options

- Across all the available options, possible restrictions regarding the collection of personal data need to be considered.. The data to be collected – **Vehicle Identification Number (VIN)**

together with distance travelled and fuel and/or energy consumed – could be considered as personal data under the General Data Protection Regulation (GDPR), if the owner of the vehicle is identifiable from the information. Where the data is considered personal data under the GDPR, a lawful basis would be needed for processing of the data

- **For data sought through a non-mandatory request, the prevailing lawful basis through GDPR is the consent of vehicle owners** to provide the requested data. **For data collected under a mandatory requirement** – whether the means is over-the-air, or through periodic technical inspections, or another route – **the lawful basis under GDPR moves from consent to ‘legal obligation’ or ‘public task’.**
- For processing of personal data, also the basic principles for processing outlined in Article 5 of the GDPR need to be complied with. For example, **the purpose of the data collection needs to be clearly defined, and no more data should be collected as necessary to fulfil the purpose.** To this end, section 5 describes the types of analyses that could be conducted depending on the data collected.

Data analysis considerations

- Several factors influence the real-world fuel consumption of vehicles and there can be considerable variation between vehicles, manufacturer fleet averages and Member State averages, as well as over time. Averaging vehicle data across vehicles and over time (one year or longer) will significantly reduce this variability.
- While aggregating the data may help to normalise some of the influencing factors, this should not remove the ability to analyse the data in detail in order to achieve a meaningful comparison with type approval data (WLTP data for LDV and VECTO data for HDV). Furthermore, aggregation should be consistent over consecutive years to ensure that averages can be compared and trends monitored.
- Average speed is an additional parameter that we recommend should be collected in order to enhance the data analysis.

Over-the-air data collection

- **Gathering real-world fuel consumption data from vehicles over-the-air (OTA) using vehicles’ existing OTA connectivity to send the data via vehicle manufacturers (Option A1) appears to be a technically feasible and effective option.**
- **There are a number of existing methods and market ready standards that can be used by the Commission to access the OBFCM data once the data are collected by the OEM.** These include the Extended Vehicle ISO standards (LDV & HDV), the Fleet Management System (FMS) technical standards (HDV), and the use of neutral servers.
- Transmitting data from a vehicle first to the OEM makes use of the OEM’s existing obligation to the vehicle owner/purchaser as a data controller.
- The majority (90%) of **LDVs** are expected to have OTA capability (outside of eCall) by 2021 with no significant bias towards particular vehicle segments. **For HDVs**, the OBFCM parameters currently defined are more commonly transmitted by HDV OTA services, although a smaller proportion of HDVs are expected to be enabled with OEM OTA systems compared to LDVs.
- **Investments would be needed by OEMs to enable this option to proceed.** HDV and LDV OEMs have already developed the associated security protocols and backend databases/servers for communicating with their vehicles and storing data, respectively; these existing systems could be used and to a small degree extended. However, not all the OBFCM parameters that must be collected and reported are currently, or planned to be, transmitted by all OEMs. Therefore, updates would also need to be made to the in-vehicle system to allow

them to be sent over-the-air. These updates are considered to be mostly a straightforward process. As the data record size is small and the transmission would be annual, the expected data transmission costs are low and should be able to be subsumed into existing OTA cellular data contracts.

- **For transmitting the OBFCM data from LDVs, it is also possible to utilise the connectivity provided by the SIM card hardware that supports 112 eCall in vehicles.** All new light duty vehicle types from 2018 have eCall hardware fitted. The record size and frequency of the OBFCM data transmission is also expected to be within the limits set for 112 eCall, and so could be incorporated into exclusive eCall data contracts. For HDV, an eCall system is not expected sooner than 2024.
- **With all the OTA options for LDVs and HDVs, there is a small risk of failure in transmitting data from vehicles.** Failures may occur in cases where the vehicle has no mobile data coverage; there is a technical malfunction that prevents OTA or corrupts the data; or SIM cards become outdated if the currently used 2G/3G networks are retired. By allowing the annual data transmission at any time of the year from the vehicle instead of at a fixed date, a more comprehensive vehicle coverage would be possible.
- **The option of direct transmission of OBFCM data from vehicles over-the-air to the Commission or EEA (Option A2)** alleviates concerns around the reliability of the data collected by OEMs and the risk of data manipulation. While there already are some third-party services accessing in-vehicle data, there is not yet a defined use-case or industry-wide solution/standard for such data transmission. This option would incur significant investment to update the OEM OTA systems and standards already in place. This option is not in-line with the Extended Vehicle standard (ISO 20077), which has been suggested as a solution for new use-cases of vehicle data access. The Extended Vehicle concept aims to limit the number of parties that have direct access to vehicle data, in order to maintain the security of connected vehicles. This option (A2) could build on the standardised eCall OTA system, which also provides an example of vehicle data transmitted to a party aside from the OEM.
- **Few actors would be required in the process of collecting data OTA.** For collecting data OTA, tens of vehicle manufacturers and the European Commission or EEA would be involved.

Periodic technical inspection data collection

- **Under Option B1, collecting data on real-world fuel consumption from vehicles would be required as part of the existing periodic technical inspections.** The obligation would lie with Member State authorities to collate data from the PTI stations and pass on to the Commission or EEA.
- **For heavy-duty vehicles, this is considered a highly appropriate option** as these vehicles' PTIs are required annually from first registration.
- **For light duty vehicles, there is a key gap in the PTI option as cars and vans do not have their first PTI until three or four years after initial vehicle registration (varying by Member State).** This means that information on the real-world vehicle fuel consumption would only become available 3 to 4 years after first registration. This is a significant time lag considering that in this portion of a vehicle life the largest annual distances are typically recorded.
- **Under Option B1, the additional effort required to gather the data on top of the existing PTI routines is expected to be minimal.** The procedure would be facilitated by the on-board diagnostic (OBD) scan tools that would be used to download the data from the vehicle. Efforts may be needed to ensure that the (independent) technical services involved in PTI have access to state-of-the-art scan tools and software.

- **The option to request Member States to voluntarily collect the real-world fuel consumption data during the period technical inspections (Option B2) is expected to lead to only some limited collection of data.**
- **Many actors would be required in the process of collecting the data through periodic technical inspections.** For the PTI option, thousands of PTI tool manufacturers and test centres, the Member State competent authorities, and the Commission would be involved.

Ad hoc sampling options

- **Ad hoc sampling via OEM vehicle servicing (Option C1) is a possible means to collect data from LDVs and HDVs during their first 1 to 2 years of operation.** Although servicing of vehicles is not a legal requirement, it is undertaken regularly during the first few years following first registration, particularly to ensure that the OEM minimum two-year warranty (legal requirement) remains valid. This could complement Option B (PTI) for light duty vehicles to address the gap prior to the first PTI. However, requiring this to occur through legislation would be challenging, as not all vehicles are presented by their owners to the OEM's authorised service centres (either choosing to take their vehicles elsewhere or omitting the service). Furthermore, OEMs have indicated that any additional costs that the OEMs would incur for carrying out these data acquisitions would need to be passed on to the consumer; and if the option was not mandatory, then very low take-up among consumers would be expected.
- **Using other vehicle emission verification activities, such as In-Service Conformity checks (Option C2), seems not to be appropriate for gathering the OBFCM data, as the sample sizes are too small.**
- **The ad hoc sampling of selected vehicle fleets (Option C3), could be considered as an alternative or be complementary to Options A1/2 (OTA) and B1 (PTI).** As data is regularly collated by fleet managers (particularly for HDV), the feasibility of data collection is high. However, there are issues relating to the representativeness of the selected sample and the potential differences in the use of fleet vehicles compared to the EU vehicle fleet as a whole. This is the case for LDV fleets in particular, such as taxis, rental vehicles and company cars, where fuel costs to the user are likely to differ which is likely to impact on how the vehicle is driven. This raises concerns regarding the suitability. Ad hoc sampling of HDV fleets, such as logistics companies, are likely to be more representative of the wider EU HDV vehicle fleet due to similar commercial usage.
- The collection of OBFCM data from a voluntarily elected sample of vehicles either via OTA or when presented to PTI is an option for sampling the fleet data (**Option C4**). As vehicle owners can decline to volunteer, there is uncertainty in the take-up rates (participation levels) of the data collection exercise and data collection would be on a smaller scale than Options A or B. This may undermine the usefulness of the exercise if insufficient data are gathered to be sufficiently representative.

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List of abbreviations

Abbreviation	Description
ACEA	European Automobile Manufacturers' Association
API	Application program interface
CAN	Controller Area Network
CARB	California Air Resource Board
CDR	Central Data Repository
C-ITS	Cooperative Intelligent Transport Systems
CO ₂	Carbon dioxide
CoP	Conformity of Production
CSV	Comma separated variable
CVUS	Canadian Vehicle Use Study
EC	European Commission
eCall	Emergency call
ECU	Engine Control Unit
EDPB	European Data Protection Board
EDPS	European Data Protection Supervisor
EEA	European Environment Agency
EMEP	European Monitoring and Evaluation Programme
EU	European Union
ExVe	Extended vehicle [concept]
FCA	Fiat Chrysler Automobiles
FMS	Fleet Management System
FOTA	Firmware Over The Air
FWHM	Full width at half maximum height
GDPR	General Data Protection Regulation
GTW	Gross Train Weight
HDV	Heavy Duty Vehicle
ICCT	International Council on Clean Transportation
ICE	Internal Combustion Engine
ICO	[UK] Information Commissioners Office
ISC	In-Service Conformity
ISO	International Organization for Standardization
kWh	Kilowatt-hour
LCV	Light commercial vehicle
LDV	Light Duty Vehicle
LTE	Long Term Evolution (LTE is a 4G [fourth generation] wireless communications standard)
M1 / M2 / M3	Passenger carrying vehicles. Category M1: fewer than 8 seats in addition to the driver's seat (cars) Category M2: more than 9 seats and mass of 5 tonnes or less (minibuses) Category M3: more than 9 seats and mass of more than 5 tonnes (buses)
MS	Member State

Abbreviation	Description
N1 / N2 / N3	Goods-carrying vehicles. Category N1: maximum mass not exceeding 3.5 tonnes (vans) Category N2: maximum mass 3.5 to 12 tonnes (trucks) Category N3: maximum mass over 12 tonnes (trucks)
NEDC	New European Drive Cycle
OBD	On board diagnostics
OBFCM	On-board fuel and/or energy consumption monitoring device
OEM	Original Equipment Manufacturer
OTA	Over the Air
OTP	Open Telematic Platform
OVC-HEV	Off Vehicle Charging – Hybrid Electric Vehicles [=PHEV]
PEMS	Portable Emissions Measurement Systems
PHEV	Plug In Hybrid Electric Vehicles
PSAP	Public Safety Answering Points
PTI	Periodic Technical Inspection
RDE	Real Driving Emissions
SAE	Society of Automotive Engineers, a standards developing organisation
SOTA	Software Over the Air
TA	Type approval
VDS	Vehicle descriptor section (part of the VIN)
VECTO	Heavy duty vehicle simulation tool
VIN	Vehicle Identification Number
VTP	Verification testing procedure
WLTP	Worldwide Harmonised Light Vehicle Test Procedure
WMI	World manufacturer identifier (part of the VIN)

1 Introduction

1.1 This report

This is the final report submitted under contract number 340201/2018/7878749/SER/CLIMA.C.4 with the European Commission DG Climate Action dated 28 September 2018 entitled “*Preparation for collection and monitoring of real world fuel consumption data for light and heavy duty vehicles*”. This report provides the findings for the study.

This report is structured as follows:

- The rest of section 1 provides the study aims (1.2) and the policy background (section 1.3)
- Section 2 outlines the study methodology
- Section 3 introduces the three main options considered for collecting and monitoring real world fuel consumption data
- Section 4 describes data protection considerations common to all options
- Section 5 introduces data analysis considerations, relevant to the options
- Sections 6 to 8 provide the findings for each of the three main options
- Section 9 provides conclusions
- Section 10 lists the references.

1.2 Study aims and objectives

This study aims to facilitate the elaboration and implementation of a systematic and periodic real-world fuel/energy consumption monitoring framework under the new Regulations setting CO₂ emission performance standards for new passenger cars and light commercial vehicles and for heavy-duty vehicles.

For new light-duty vehicles (LDV), the real-world fuel and/or energy consumption data will be collected using standardised on-board fuel and/or energy consumption monitoring devices (OBFCM devices) as required from 2021 on by Commission Regulation (EU) 2018/1832 of 5 November 2018 (known as the WLTP 2nd amendment) . Regulation (EU) 2019/631 setting CO₂ emission standards for new cars and vans empowers the Commission to adopt the data collection and reporting procedures in an implementing act.

For heavy-duty vehicles (HDV), the similar provisions on the data collection, reporting and mandating the use of OBFCM devices are set out in the new Regulation setting CO₂ emission standards¹, but the OBFCM standardisation legislation is still in preparation.

The primary focus of this study is in assessing the practicability of managing the data flows from the vehicles to the European Commission.

¹ Published in the Official Journal L 198, on 25.7.2019, p. 202–240 at <https://eur-lex.europa.eu/eli/reg/2019/1242/oj>

1.3 Background and legislative framework

1.3.1 Light Duty Vehicles (LDV) CO₂ regulations and type approval

The European Commission first introduced mandatory CO₂ targets for passenger cars in 2009 and for light commercial vehicles (LCV) in 2011. In 2014, stricter CO₂ targets were set for 2020 (LCV) and 2021 (cars). New 2025 and 2030 CO₂ targets for cars and vans (LDV) were set by the European Parliament and the Council in the recently published Regulation (EU) 2019/631 of 17 April 2019 setting CO₂ emission performance standards for new passenger cars and for new light commercial vehicles, and repealing Regulations (EC) No 443/2009 and (EU) No 510/2011.²

Compliance with the mandatory targets is based on CO₂ emission data determined through type approval (TA) testing that consists of chassis dynamometer (i.e. whole vehicle) testing using a well-defined procedure. Until recently, this was based on the New European Drive Cycle (NEDC), which has recently been replaced by the Worldwide Harmonised Light Vehicle Test Procedure (WLTP). While the WLTP is being phased-in between 2017-2020, NEDC values (converted back from WLTP values through the 'CO2MPAS' simulation tool developed for this purpose) will continue to be used for target compliance checking. From 2021 on, target compliance checking will be based on the WLTP data.

The effectiveness of targets set using this methodology to reduce CO₂ emissions from on-road driving depends on how representative the TA test is of real-world vehicle operation; as well as on the extent to which the vehicles placed on the market conform to the reference vehicles tested at TA.

For the purpose of monitoring the CO₂ emissions of newly registered passenger cars and light commercial vehicles and to allow an assessment of manufacturers' compliance with their targets, the European Environment Agency (EEA) collects data on all the vehicles newly registered in each Member State for each vehicle manufacturer. Data are collected for individual vehicles. This includes data on the vehicle manufacturers, the Vehicle Identification Number (VIN), the type approval CO₂ value (NEDC and, where available, WLTP), vehicle mass, etc. Due to privacy reasons, the VIN are not published. This means the monitoring of data for ~15,000,000 new cars and ~1,000,000 new vans per year.

Existence of a gap between real-world CO₂ emissions and laboratory testing values

From as early as 2005, it has been recognised that a gap exists between real world and official value for CO₂ emissions (IEA, 2005). This gap is largely the result of limitations in the test procedure to replicate real world driving, although the process has been widely improved for both LDVs and HDVs. Fontaras et al. (2017) provide a comprehensive overview of the factors that influence fuel consumption and CO₂ emissions on the road and contribute to the gap. They include:

- Vehicle characteristics (e.g. vehicle load and aerodynamics)
- The use of auxiliary systems fitted to the vehicle
- Vehicle maintenance and ageing
- External factors (e.g. weather, altitude, road conditions and traffic conditions)
- Driver factors (e.g. driving style and fuel choice)

These factors are difficult to quantify and are not constrained to remain constant, which makes the effectiveness of CO₂ targets based on TA values uncertain.

For plug-in hybrid electric vehicles (PHEVs), an additional complicating element is that the energy used to move the vehicles comes from a combination of externally supplied electricity to power the traction motor(s) and from any additional fuel used by the internal combustion engine (ICE).

² <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32019R0631>

Changes in the gap over time

Evidence from a number of sources has indicated a growing divergence between the CO₂ emissions determined at TA using NEDC, and the on-the road performance of vehicles (Ligterink & Smokers, 2016; Tietge et al., 2017; Pavlovic et al. 2017). Evidence shows that there was an increase in divergence following the introduction of mandatory CO₂ targets that have been set for LDVs since 2009 (Tietge et al, 2016). Wegener et al. (2016) suggested (and Fontaras et al., 2017 implied) that these trends can be explained by pressure to adhere to EU emissions regulation that has resulted in:

- the introduction of new vehicle technologies that provide fewer benefits under real-world driving conditions compared to TA testing; and
- increasing optimisation of the performance of vehicles under the TA test by greater utilisation of flexibilities in the process. This refers to a procedural interpretation or absence of a provision that can result in lower measurements of CO₂ emissions. The range of 'flexibilities' or 'elasticities' and their potential influence on CO₂ emissions are summarised in Fontaras et al. (2017).

Since 2012, the International Council on Clean Transportation (ICCT) has released annual reports on the gap between the official and "real-world" fuel consumption and CO₂ values for passenger cars in Europe ('From Laboratory to Road'). This series of publications has presented evidence that the gap has been growing, from about 8% in 2001 to 42% in 2015 (Mock et al., 2012 & Tietge et al., 2016). The latest report (Tietge et al., 2019) indicates that the gap plateaued after 2015 and suggests several factors that may explain this plateauing (paraphrased from the ICCT report):

- Less regulatory pressure on vehicle manufacturers in the immediate years after the 2015 CO₂ targets were met;
- Fewer new models and model generations marketed by manufacturers in the lead up to regulatory changes such as WLTP and Real Driving Emissions (RDE) tests;
- No further TA optimisation (either due to exhausting most flexibilities, or to avoid increased scrutiny);
- A reduction in the share of new diesel vehicle registrations following recent concerns of diesel vehicle emissions;
- Seasonal bias in the data collection methodology, as data was collected later in the year for this study compared to the previous 'From Laboratory to Road' studies.

Issues with the divergence between real-world CO₂ emissions and laboratory testing values

The existence of a gap is not an issue per se as long as it is known and remains constant over time. In that case, a correction factor can be applied to account for the real-world CO₂ emissions of the vehicle fleet (Wegener et al., 2016). However, the gap becomes a problem if it widens over time, such that progress in reducing CO₂ emissions only occurs under testing rather than on the road. This has several negative implications, the most direct being a decrease in the effectiveness of policies aimed at reducing CO₂ emissions on the road. Within the industry, a growing divergence may also stifle innovation if CO₂ targets appear to be met following conventional approaches. Furthermore, inaccurate labelling information based on type-approval emission values could mislead consumers, reducing the appeal of lower emission technologies or vehicles.

Steps taken to address the gap and the divergence

The new **WLTP** laboratory test was adopted in June 2017 and applied to the type approval process from September 2017. It includes more stringent test requirements and a test cycle more closely reflecting real world driving. Compared to the NEDC, the WLTP tends to increase the CO₂ emissions measured during the test procedure, which may result in an approximately 25% increase in fleet-wide average CO₂ emissions estimates (Pavlovic et al., 2018). The change to WLTP is expected to reduce

the gap between official test values and real-world emissions by about half (Fontaras et al. 2017). However, inevitably a gap will still remain as a laboratory test cannot mimic all operations and conditions occurring on the road. For example, WLTP testing is undertaken without auxiliary energy consuming devices such as air conditioning, lights or wipers in use, while a significant proportion of real driving occurs with these additional loads on the engine.

In April 2019, Regulation (EU) 2019/631 was adopted, setting new post-2020 CO₂ emission performance standards for new passenger cars and for new light commercial vehicles³. The Regulation contains two main new elements to address a possible future increase of the gap between WLTP type approval CO₂ and real-world CO₂ emissions – (i) through verification of emissions in-service and (ii) by collecting data on real world fuel consumption from on-board fuel and/or energy consumption monitoring devices (OBFCM devices), starting with new passenger cars and new light commercial vehicles registered in 2021.

The provisions concerning the second point are set out in Article 12 of the Regulation, which stipulates that the Commission shall:

- ensure that the following parameters are made available at regular intervals to it, from manufacturers, national authorities or through direct data transfer from vehicles:
 - (a) vehicle identification number;
 - (b) fuel and/or electric energy consumed;
 - (c) total distance travelled;
 - (d) for externally chargeable hybrid electric vehicles, the fuel and electric energy consumed and the distance travelled distributed over the different driving modes;
 - (e) other relevant parameters;
- process the data received to create anonymised and aggregated datasets, including per manufacturer - the vehicle identification numbers shall be used only for the purpose of that data processing and shall not be retained longer than needed for that purpose;
- ensure that the public is informed of how the real-world representativeness of the WLTP type approval emission values evolves over time;
- no later than 1 June 2023, assess how fuel and energy consumption data may be used to ensure that the WLTP type approval values remain representative of real-world emissions over time for each manufacturer;
- monitor and report annually on how the gap evolves over the period 2021 to 2026.

The Commission shall adopt the detailed procedure for collecting and processing the data by means of implementing acts.

Requirements for the type-approval of the OBFCM device

In November 2018 the Commission adopted Regulation (EU) 2018/1832 (known as the **WLTP 2nd amendment**)⁴, which *inter alia* amends Regulation (EU) 2017/1151 (WLTP) by adding requirements for type-approval regarding devices for monitoring the consumption of fuel and/or electric energy. The relevant provisions are provided in full in Appendix C to this report.

The new Article 4a of Regulation (EU) 2017/1151 sets an obligation for manufacturers to ensure that new light-duty vehicles⁵ are equipped with a device for determining, storing and making available data

³ <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R0631&from=EN>

⁴ <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2018:301:FULL&from=EN>

⁵ With introduction dates varying from 1/1/20 for new vehicle types, 1/1/21 for all cars and Class 1 vans, and 12 months later for Class 2 & 3 vans

on the quantity of fuel and/or electric energy used for the operation of the vehicle. It concerns vehicles powered exclusively by mineral diesel, biodiesel, petrol, ethanol or any combination of these fuels as well as PHEVs powered by electricity and any of the aforementioned fuels.

The new Annex XXII to Regulation (EU) 2017/1151 sets out the requirements for the device for monitoring the consumption of fuel and/or electric energy. It lists the information that shall be determined, stored and made available, *for all vehicles*:

- (a) Total fuel consumed (lifetime) (litres);
- (b) total distance travelled (lifetime) (kilometres);
- (c) engine fuel rate (grams/second);
- (d) engine fuel rate (litres/hour);
- (e) vehicle fuel rate (grams/second);
- (f) vehicle speed (kilometres/hour).

For OVC-HEVs, in addition to the abovementioned, also:

- (g) total fuel consumed in charge depleting operation (lifetime) (litres);
- (h) total fuel consumed in driver-selectable charge increasing operation (lifetime) (litres);
- (i) total distance travelled in charge depleting operation with engine off (lifetime) (kilometres);
- (j) total distance travelled in charge depleting operation with engine running (lifetime) (kilometres);
- (k) total distance travelled in driver-selectable charge increasing operation (lifetime) (kilometres);
- (l) total grid energy into the battery (lifetime) (kWh).

Only the parameters referred to as “lifetime” values are those which are required to be stored in the vehicle and made available for download at a future point. The other parameters are “instantaneous” values that are accessible live on the vehicle but are not stored.

For the more detailed technical requirements, the Regulation refers to a number of ISO standards, i.e. parts of ISO 15031 and ISO 15765. The parameters shall be calculated and scaled according to ISO 15031-5. The OBFCM device shall provide for standardised and unrestricted access of the information, conforming to ISO 15765-4 and ISO 15031-5. The information shall be made available as signals through the serial port connector referred to in ISO 15031-3.

ISO 15031 is an international standard that draws on SAE (Society of Automotive Engineers) recommended practices. It consists of seven parts that together provide a coherent set of specifications to support diagnostics of vehicle emissions. Two of the parts have been referenced in the OBFCM regulation and relate to the transmission of on-board diagnostic (OBD) relevant information:

- ISO 15031-3 “Road vehicles – Communication between vehicle and external test equipment for emissions related diagnostics Part 3: Diagnostic connector and related electrical circuits: specification and use”, (SAE J1962 equivalent). This describes the requirements for the physical connection and associated pin usage to allow for standard access to the OBD data.
- ISO 15031-5 “Road vehicles - Communication between vehicles and external test equipment for emissions-related diagnostics – Part 5: Emissions-related diagnostic services”. (SAE J1979 equivalent). This is intended to satisfy the data reporting requirements of OBD regulations.

ISO 15765 is an international standard that covers diagnostic communication over Controller Area Networks. Part 4 of this standard has been referenced in the OBFCM regulation in relation to the on board to off-board communications link:

- ISO 15765-4:2011 “Road vehicles – Diagnostics on Controller Area Network (CAN) – Part 4: Requirements for emissions-related systems”. This specifies requirements for Controller Area Networks (CAN) where one or more controllers comply with on-board diagnostics (OBD).

By way of exemption from the reset conditions specified in those standards, once the vehicle has entered into service the values of the lifetime counters shall be preserved.

The values of the lifetime counters may be reset only for those vehicles for which the memory type of the engine control unit is unable to preserve data when not powered by electricity. For those vehicles the values may be reset simultaneously only in the case the battery is disconnected from the vehicle. The obligation to preserve the values of the lifetime counters shall in this case apply for new type approvals at the latest from 1 January 2022 and for new vehicles from 1 January 2023.

In the case of malfunctioning affecting the values of the lifetime counters, or replacement of the engine control unit, the counters may be reset simultaneously to ensure that the values remain fully synchronised.

The manufacturer shall ensure that the OBFCM device provides the most accurate values that can be achieved by the measurement and calculation system of the engine control unit. The indicated fuel consumption is to be within 5% of the real fuel consumption value.

There is no requirement for vehicles to report values prior to a vehicle system needing to reset them.

Summary

Mandatory CO₂ targets are a core element of the Commission’s strategy for improving the fuel economy of cars and vans sold in the European market. Compliance with these targets relies upon laboratory testing of vehicles in a type approval process, which is known to yield lower CO₂ emission values than on the road driving. A growing divergence between real-world emissions and TA values has been identified, which could undermine the effectiveness of the vehicle CO₂ regulations. The introduction of the WLTP should significantly contribute to a reduction in the gap between test cycle and real-world emissions performance. Under the new Regulation setting post-2020 LDV CO₂ emission standards, the Commission will monitor real-world CO₂ emissions with a view to assess the representativeness of the type-approval emission values. For this, data from the on-board fuel consumption monitoring devices will be used. Under the WLTP 2nd amendment, such devices will soon become mandatory in all new LDV. The real-world fuel consumption data collection and reporting procedures need to be set out in implementing acts under the LDV CO₂ regulations.

1.3.2 Heavy Duty Vehicle (HDV) CO₂ regulation and certification

For HDVs, the situation is a bit less mature. The new Regulation (EU) 2019/1242 setting CO₂ emission standards for heavy-duty vehicles⁶ sets requirements regarding the monitoring and assessment of real-world representativeness of the official test CO₂ emissions, which are very similar to those under the LDV Regulation.

The Commission shall collect data from on-board fuel consumption monitoring devices, following the same approach as the LDV regulations. However, as the implementing legislation that establishes the requirement to fit the HDVs with OBFCM still needs to be prepared, no precise timing has been established in the Regulation. Furthermore, an additional parameter to be monitored for HDVs is the payload, which can vary greatly and significantly influences a vehicle’s fuel consumption.

The HDV CO₂ emission standards are based on a “virtual laboratory” using characterised key components (e.g. the engine, gearbox etc.) and a vehicle CO₂ simulator (VECTO). For HDVs the objective is therefore to monitor the real-world representativeness of the output of VECTO. The

⁶ <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R1242&from=EN>

Commission is also developing an on-road verification testing procedure (VTP) for HDVs that will be used as a procedure for monitoring the Conformity of Production (CoP) of the vehicle. It will become a new Annex to Regulation 2017/2400.

Reflecting the status of policy development, there is a greater emphasis on LDVs than HDVs in this study.

1.3.3 SIM card device used to support eCall service

Since April 2018, Regulation (EU) 2015/758⁷ requires all new types of vehicles in categories M1 and N1 registered in the EU to be equipped with a device to make an automatic call to the emergency services on number 112 in the event of a serious accident, reporting the vehicle's position and direction and time of the incident. This requirement is known as 'eCall'; the Commission Implementing Regulation (EU) 2017/78 and Commission Delegated Regulation (EU) 2017/79 contain the associated administrative and technical details respectively. Regulation (EU) No 305/2013 specifies the deployment of eCall in emergency call centres (Public Safety Answering Points – PSAPs), while Decision (EU) No 585/2014 mandates the deployment of the PSAPs infrastructure.

The purpose of the legislation is to speed up the response times of the emergency services attending an accident, aiming to reduce the number of fatalities and the severity of injuries. An eCall can also be triggered manually by pushing a button in the car, for example by a witness to a serious accident.

The eCall requirements are relevant to this study as it means that (certain) new M1 and N1 vehicles will have the hardware installed with the capability to send data from the vehicle. Recitals (15) and (16) include relevant notions in this context as highlighted in underlined bold below. This hardware functionality is considered in this study as one of the options considered for making real world fuel consumption data available to the Commission.

Regulation (EU) 2015/758 concerning type-approval requirements for the deployment of the eCall in-vehicle system based on the 112 service and amending Directive 2007/46/EC

(...)

(15) **The mandatory equipping of vehicles with the 112-based eCall in-vehicle system should be without prejudice to the right of all stakeholders such as car manufacturers and independent operators to offer additional emergency and/or added value services, in parallel with or building on the 112-based eCall in-vehicle system. (...)**

(16) (...) **the eCall in-vehicle systems should be based on an interoperable, standardised, secure and open-access platform for possible future in-vehicle applications or services. (...)**

1.3.4 Roadworthiness Directive

In 2014 the European Union adopted a package of three Directives aiming to improve road safety through minimum common requirements for annual roadworthiness tests and roadside inspections of all vehicles within the EU. This included Directive 2014/45/EU on periodic roadworthiness tests, referred to as Periodic Technical Inspections (PTI), which replaced the previous Directive 2009/40/EC. Directive 2014/45/EU sets out the maximum periodicity for inspections of vehicles by authorised testing centres.

The Directive requires all M1 and N1 vehicles to be inspected (at a minimum) four years after the vehicles are registered and then every two years subsequently.

Member States may choose to implement requirements for more frequent inspections than this – for example Malta and the United Kingdom require inspections of M1 and N1 vehicles three years after registration and then annually thereafter.

⁷ https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2015.123.01.0077.01.ENG

For HDVs, the Directive requires all M2/3 and N2/3 vehicles to be inspected (at a minimum) annually from 1 year after the vehicles are registered.

The requirement for vehicles to be inspected periodically by an authorised testing centre offers the opportunity for data to be systematically recorded and analysed. This is considered in this study as one possible route to obtaining the data, offering a more complete coverage of data – and, by extension, fuel consumption data – than is currently available via over-the-air (OTA) enabled vehicles.

1.3.5 The Extended Vehicle concept

As vehicles become increasingly connected, the demand for vehicle data also increases. To manage the number of third parties that can have direct access to a moving vehicle, the 'extended vehicle' concept promotes safe and secure access to vehicle data via an off-board facility. An ISO standard (20077/8) has been developed that standardises the means of off-board access and its interfaces, and ensures interoperability. The vehicle manufacturer is the data handler and provides third parties with access to vehicle data in accordance with technical, data protection and competition rules, through interfaces and means of off-board data storage. Controlled off-board access to the data removes the need to have direct access to the vehicle, which increases the safety and security and reduces the liability risks associated with direct access. In the Working Group 6 report of the C-ITS platform (C-ITS Platform, 2015), ACEA suggested that for new use cases of in-vehicle data access, the Extended Vehicle standard should be used.

2 Methodology

This study has drawn upon two main sources of information:

- A literature review
- A stakeholder consultation exercise

2.1 Literature review

Literature sources identified in the Terms of Reference were supplemented with additional sources identified by the study team. A full list of references is included in section 10. The findings from the literature review are included in Appendix A.

2.2 Stakeholder consultation

Stakeholder consultation has been carried out through the use of questionnaires tailored to relevant stakeholder groups, followed up with selected telephone interviews. The stakeholder groups contacted included: light and heavy-duty vehicle manufacturers; Member State national authorities responsible for type approval and periodic technical inspections; selected fleet operators; and other interested stakeholders.

Survey questions agreed with DG CLIMA were aimed at each of the main stakeholder groups (vehicle manufacturers, national authorities and fleet operators), and further tailored questionnaires for other stakeholders. The questions were developed to explore the main aspects of the related proposed options. The survey questions were developed to enable stakeholders to respond to them in writing, but also be used as a basis for a telephone interview.

For the majority of stakeholder groups, targeted contacts were identified at the start of the study, in particular for OEM/vehicle manufacturers and national authorities. Other potential contacts were identified via the study team, respecting GDPR requirements.

The consultation period varied by stakeholder group, with the earliest consultation element beginning in January 2019, and the concluding in May 2019.

Transcripts of interviews, which have been agreed with the interviewees, have been used to record the discussions that have taken place and are included in Appendix B. These transcripts have been anonymised in the case of vehicle manufacturers.

For the Member State national authorities, a shortlist of four Member States was agreed with the Commission at the study outset to be the focus of the stakeholder engagement. These were France, Germany, the Netherlands and the United Kingdom. Some further feedback from organisations in other Member States was obtained through consulting the International Motor Vehicle Inspection Committee (CITA) who in turn consulted its members that included representation from across other EU Member States.

The table in Appendix B lists the organisations that have been contacted and which have contributed to this study. The authors are grateful for the stakeholders that engaged in the study.

3 Options considered for collecting and monitoring real world fuel consumption

The three main options considered for monitoring and reporting the real-world fuel and energy consumption of light- and heavy-duty vehicles are:

- A. An obligation for vehicle manufacturers to enable the periodic transmission of real-world fuel and/or energy consumption of vehicles using the over the-air (OTA) connectivity of the vehicles.
- B. An obligation for/request to national authorities to collect periodically the average real-world fuel and/or energy consumption of vehicles as part of the periodic technical inspections (PTI), and report it to the European Commission or EEA.
- C. Regular "ad-hoc" fleet sampling by the Commission or by Member States on behalf of the Commission.

These options are considered in detail and appraised for their advantages and disadvantages in the subsequent sections of this report. The options are not mutually exclusive and the merits of combining them have been considered. Table 3-1 summarises the distinguishing features of the options among the various aspects considered.

Table 3-1: Summary of considerations for each Option (LDV and HDV, except where noted differently)

Consideration	Option A: OTA reporting	Option B: collection by Member States through PTI	Option C: sampling
Sub-options	(1) Reporting of data OTA from the vehicle to OEMs, who subsequently send to the Commission/EEA. (2) Reporting of data OTA from the vehicle directly to the Commission/EEA.	(1) Legal requirement (2) Voluntary collection (request from the Commission)	(1) Manufacturers collect from vehicles at servicing. (2) Through other vehicle verification activities (e.g. in-service conformity testing) (3) Fleet managers collect from vehicles. (4) Ad-hoc sampling through OTA or PTI
Coverage	All vehicles that have OTA capability. Coverage will evolve over time according to OTA fleet penetration.	All vehicles registered that are presented for PTI, coverage should be complete, but frequency varies by Member State. LDV frequency is lower than HDV frequency. Could consider sampling.	Varies by sub-option. Potential for selection bias.
Data contents to be reported	Data required for reporting under the CO ₂ Regulations. Different data for LDV-PHEV, LDV-ICE, HDV. Consider option of just ratio of fuel/distance (g/km).		

Consideration	Option A: OTA reporting	Option B: collection by Member States through PTI	Option C: sampling
Data flow / stakeholders	(1) Vehicle→OEM [OTA], OEM→EC [not OTA]. (2) Vehicle→EC [OTA]. Additional stakeholders may be involved in data processing stages (e.g. contracted by vehicle manufacturers or by EC).	Vehicle→PTI station [OBD download], PTI station → MS [web database], MS→ EC/EEA [web database]. Additional stakeholders may include EEA, JRC, third party contractor to process data, representation of inspection stations.	(1) Vehicle→OEM* [not OTA], OEM→EC/EEA [not OTA]. (2) Vehicle →MS [not OTA], MS→EC (3) Vehicle→fleet manager [OTA or OBD], Fleet manager →EC [web database]. (4) as per Options A or B. Additional stakeholders may be involved in data processing stages (e.g. contracted by fleet managers or by EC).
Aggregation / anonymisation processing options	Sub-options: a) No aggregation: data per vehicle transmitted to the Commission. b) Data per vehicle aggregated to the level of interpolation family or other ⁸ , either by manufacturer, or by EC. c) Aggregated to manufacturer level, in data processing by EC.	Sub-options: a) No aggregation: data per vehicle uploaded to MS authority, and transmitted from MS authority to EC. b) Data per vehicle aggregated to the level of interpolation family or other, by MS authority or by EC. c) Aggregated to manufacturer level, in data processing by EC	Sub-options: a) No aggregation: data transmitted per vehicle from fleet managers to EC. b) Data per vehicle aggregated to the level of interpolation family or other, by fleet manager or by EC c) Aggregated to manufacturer level, by fleet manager or by EC
Frequency / coverage of data collection	OTA can be annual or more/less frequent.	LDV PTI after 3 or 4 years, then every 1 or 2 years. HDV PTI frequency is annual from 1 st year of registration.	Annual or more frequent. Servicing: no guarantee of frequency as may be annual or more or less frequent.

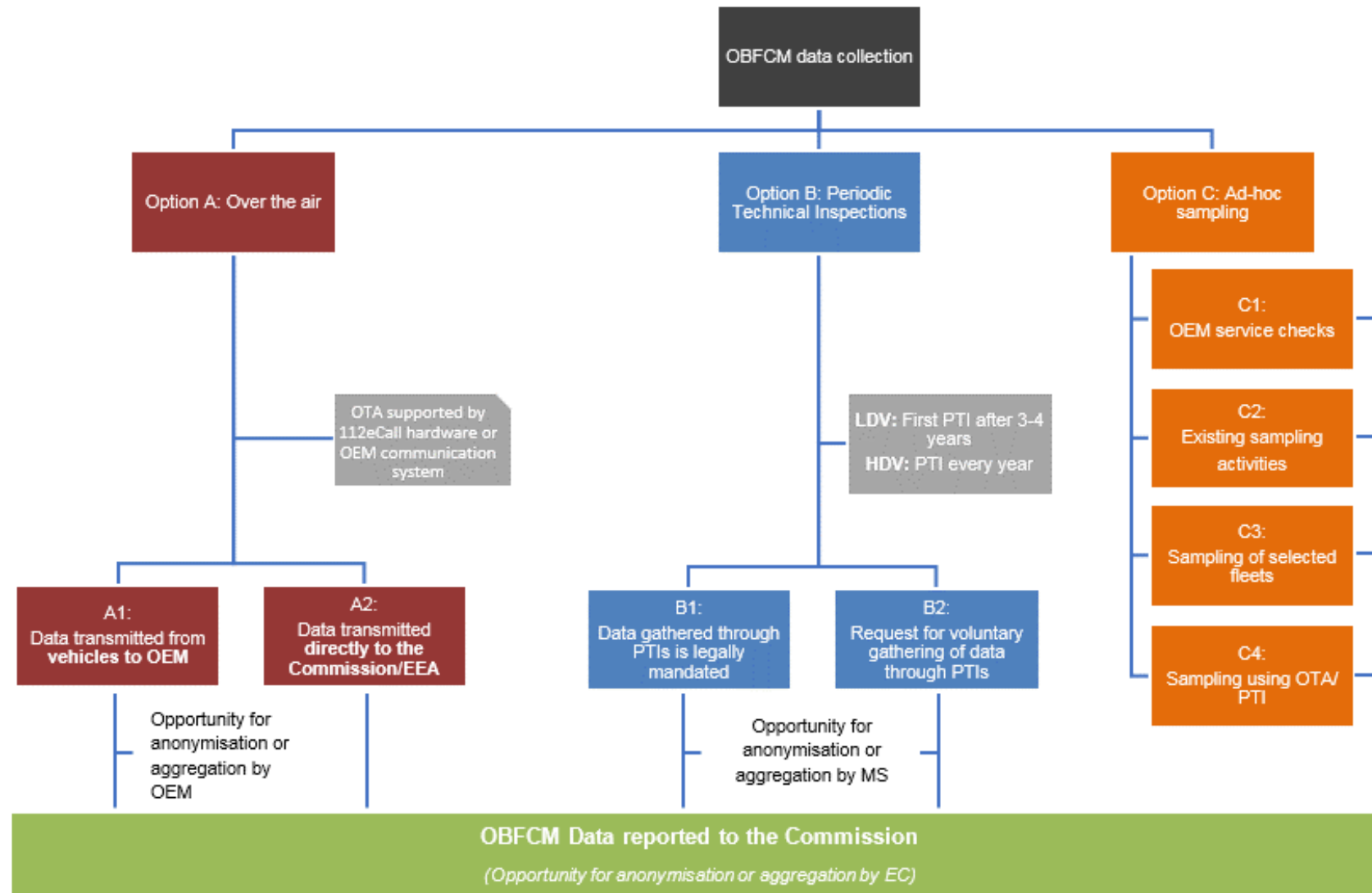
* Or for options C1 or C4 could be service provider rather than OEM.

The options are summarised in Figure 3-1 and considered in further detail in the subsequent sections.⁹

⁸ Further information on options for aggregation is in section 5.2.4.

⁹ Stakeholders also suggested additional options to collect real world fuel consumption data. Multiple vehicle manufacturers and other stakeholders suggested utilising the point at which vehicles use a fuel/recharging station. It was suggested that a WIFI-based system installed at such locations could automatically scan license plate numbers and record fuel or electricity supplied to that vehicle using the existing high-accuracy pump meters, with the odometer reading needing to be additionally read. The possible fallibility of this setup would be that, in order to obtain a comprehensive picture of fuel consumption for each vehicle, then all fuel/energy sold to the vehicle from any location (including, for energy, at locations such as people's homes) would need to be accounted for. As this suggestion does not appear to involve the OBFCM it has not been discussed further.

Figure 3-1 Summary of Options



4 Data protection considerations common to all options

4.1 Relevant Data Protection legislation

Regulation (EU) 2016/679¹⁰ (**General Data Protection Regulation (GDPR)**) was adopted in May 2016 and has applied across the EU since 25 May 2018. It repeals its predecessor, Directive 95/46/EC¹¹ (**Data Protection Directive**).

According to Article 1 of the GDPR, the Regulation lays down rules relating to the protection of **natural persons** with regard to **processing of personal data**. Recital 14 of the GDPR further explains that the protection afforded by the Regulation should apply to natural persons, whatever their nationality or place of residence, in relation to the processing of their personal data. The Regulation does not cover the processing of personal data which concerns legal persons and in particular undertakings established as legal persons.

According to Article 2(3) of the GDPR, for the processing of personal data by the Union institutions, bodies, offices and agencies, Regulation (EU) 2018/1725¹² applies. The Regulation provisions however align with the GDPR, and so the study will therefore concentrate on the GDPR.

4.2 Definition of personal data

It is important to understand what constitutes personal data in terms of applicability of the GDPR.

According to Article 4(1) of the GDPR, personal data is “*any information **relating to** [emphasis added] an **identified or identifiable** [emphasis added] natural person (‘data subject’); an identifiable natural person is one who can be identified, **directly or indirectly** [emphasis added] in particular by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person*”.

It follows from the definition that there are two important elements to consider for the data to classify as personal data: (1) the information must ‘relate to’ an individual and (2) that individual must be identified or identifiable, either directly or indirectly.

Article 12(1) of Regulation (EU) No 2019/631 instructs the Commission to regularly collect data on the real-world CO₂ emissions and fuel or energy consumed of passenger cars and light commercial vehicles using on-board fuel and/or energy consumption monitoring devices, starting with new passenger cars and new light commercial vehicles registered in 2021. According to Article 12(2) of the same Regulation, the Commission shall ensure that VIN, fuel consumption and distance travelled data are made available at regular intervals to it, from manufacturers, national authorities or through direct data transfer from vehicles, as the case may be. According to the amendments of Regulation (EU) 2017/1151 through

¹⁰ Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC, OJ L 119, 4.5.2016, p. 1–88

¹¹ Directive 95/46/EC of the European Parliament and of the Council of 24 October 1995 on the protection of individuals with regard to the processing of personal data and on the free movement of such data, OJ L 281, 23.11.1995, p. 31–50

¹² Regulation (EU) 2018/1725 of the European Parliament and of the Council of 23 October 2018 on the protection of natural persons with regard to the processing of personal data by the Union institutions, bodies, offices and agencies and on the free movement of such data, and repealing Regulation (EC) No 45/2001 and Decision No 1247/2002/EC, OJ L 295, 21.11.2018, p. 39–98

Regulation (EU) No 2018/1832, the OBFCM device will determine and store the data on total lifetime fuel consumed and distance travelled.

Firstly, in relation to the “relates to” element of the personal data definition, Article 29 Working Party¹³ opinion 4/2007 provides that “*data relates to an individual if it refers to the identity, characteristics or behaviour of an individual or if such information is used to determine or influence the way in which that person is treated or evaluated*”. The opinion also states that “*In some situations, the information conveyed by the data concerns objects in the first instance, and not individuals. Those objects usually belong to someone, or may be subject to particular influence by or upon individuals or may maintain some sort of physical or geographical vicinity with individuals or with other objects. It is then only indirectly that it can be considered that the information relates to those individuals or those objects.*” (EC, 2007).

It follows, strictly speaking, that the data on total lifetime fuel consumption and distance travelled, as in Regulations (EU) No 2019/631 and 2018/1832, concern the vehicle and not the driver. However, vehicles are assets of their owners and in particular in case of private vehicles, mostly driven by their owners, and therefore, the data can, in certain circumstances, provide information about the owners’ activities – the distance that they travel or fuel they consume.

Second, in order to identify whether the data could classify as personal data in terms of the GDPR, it is important to assess whether the individual is identified or identifiable from the collected data. As Article 29 Working Party opinion 4/2007 clarifies, the identification can occur (1) directly from the information in question; or (2) indirectly from that information in combination with other information (i.e. it is not necessary that the information alone allows the data subject to be identified) (EC, 2007). The definition of the personal data is therefore not about the nature of the data, but about a person’s ability to identify an individual person behind that data (Osbourne Clarke, 2017), and hence the same information can be personal data in one person’s hand, but not another.

Regarding the ability to identify an individual directly from the information, it is unlikely that information on fuel consumed, distance travelled or VIN *in itself* constitute information relating to an identified natural person, as the information does not directly reveal the identity of the vehicle owner or any driver who might also be using the vehicle.¹⁴

It is however important to assess whether the collected data, if combined with other information, could make the individual indirectly identifiable. Regarding the data on fuel consumed/ distance travelled (without VIN), it is unlikely that it is personal data as it lacks personal identifier and cannot therefore be linked to an individual. VIN¹⁵ is however unique to a vehicle and therefore, if used with other information, may allow the registered owner of the vehicle to be singled out and as a result their identification. Therefore, the data on fuel consumed/ distance travelled coupled with VIN could become a personal data.

Recital 26 of the GDPR states that, to determine whether or not the individual is identifiable one should take into account “*all the means reasonably likely to be used, such as singling out, either by the controller or by another person to identify the natural person directly or indirectly*”. In Case-582/14, the

¹³ Article 29 Working Party was set up under Article 29 of the Data Protection Directive as an advisory body. It composed of representatives of Member States data protection authorities, the European Data Protection Supervisor and the European Commission. The body was replaced by the European Data Protection Supervisor under the GDPR. While Article 29 Working Party opinions were issued in regards to the Data Protection Directive, the concept and qualification of personal data remain unchanged in the GDPR (Osbourne Clarke, 2017) and therefore Article 29 Working Party opinions can still be considered to pose the point of reference for the application of data protection legislation.

¹⁴ There is however some lack of clarity in the market as to whether VIN data *in itself* could constitute a personal identifier and therefore personal data. For example, SMMT (2017) considers a VIN as a personal identifier, and therefore where vehicle fuel consumption data is tied to VIN data, the data becomes personal data.

¹⁵ Data transferred OTA could also include other unique identifiers.

European Court of Justice further explained, in relation to the Data Protection Directive, that for information to be treated as personal data, it is not required that all the information enabling the identification of the data subject must be in the hands of one person. Data is treated as personal data in the hands of a person if that person can obtain by legal means sufficient additional data to link the information to a person and therefore identify that person.¹⁶

It is therefore important to assess whether the data in the hands of a particular person could become personal data when combined with additional data the person could have access to by all the means reasonably likely to be used. As there are several options under consideration in the scope of the study, each concerning different parties in data collection process, the data in the hands of the parties will be assessed separately.

There are differing views amongst stakeholders whether VIN data combined with data on fuel consumed/ distance travelled constitute personal data:

UK Driver and Vehicle Licensing Agency: *"The UK's opinion is that VRN/VIN is not considered personal information on its own as it does not reveal any information about the individual. It is only when this information is linked to further information that together could be considered personal (such as VRN and GPS data) that it could be problematic. However, VRN (or VIN) with mileage and fuel consumption information should not be considered personal information as it does not reveal location or who is driving."*

OEM: *"Vehicle manufacturers would need to have a valid legal basis for processing such data since data protection authorities hold the view that this data, when combined with the VIN, constitute "personal data" in the sense of article 4(1) of the GDPR."*

Verbraucherzentrale Bundesverband e.V.: *"By linking the vehicle identification number (VIN), a personal link to the owner and holder is possible even with initially exclusively technical data, so that as a result all data occurring in the vehicle fall under the regulations of the GDPR."*

Article 29 Data Protection Working Party Opinion 4/2007 however further provides *"Where identification of the data subject is not included in the purpose of the processing, the technical measures to prevent identification have a very important role to play. Putting in place the appropriate state-of-the-art technical and organizational measures to protect the data against identification may make the difference to consider that the persons are not identifiable, taking account of all the means likely reasonably to be used by the controller or by any other person to identify the individuals."* (EC, 2007)

Vehicle manufacturers

In regard to vehicle manufacturers, it is widely considered that the majority of data in connected vehicles are personal data, as vehicle manufactures can identify at least the vehicle owner with reasonable efforts, for example, the vehicle manufacturers will have this possibility through sales contracts, or through their dealership networks (Osbourne Clark, 2017). The identification will however be less likely where the vehicle has moved to the second hand market, and/or use independent service providers for maintenance and repair.

Competent authorities of the Member States or roadworthiness testing centres

Roadworthiness Directive (EU) No 2014/45/EU requires Member States to ensure that testing centres or, if relevant, the competent authorities, carry out roadworthiness tests of vehicles at regular intervals, as specified in the Directive. The testing centres share the data with national competent authorities, and vehicle registration registries.

¹⁶ Case C-582/14 concerning the interpretation of Article 2(a) and 7(f) of Directive 95/46/EC (since repealed by Regulation (EU) 2016/679), available at: <http://curia.europa.eu/juris/document/document.jsf?docid=184668&doclang=EN>

The national competent authorities will have access to vehicle registration registries where details on vehicles and their owners are stored, therefore the fuel consumption and distance travelled data with VIN is likely to constitute personal data in the hands of competent authorities. Similarly, the testing centres can have access to the registries to submit the testing data, also the testing centres as customer's contractual service providers are aware of their customer's identity and can therefore link the data to the customer (Osbourne Clarke, 2017).

European Commission

When considering whether the collecting of the data by the Commission would constitute processing of personal data, it would be important for the Commission to consider whether they would have the means which may likely reasonably be used in order to identify the data subject, including with the assistance of other persons, such as the national competent authorities or vehicle manufacturers.

For example, in case Case-582/14, the European Court of Justice found that even though the national legislation did not allow the internet service provider to transmit directly to the online media services provider the additional data necessary for the identification of the data subject, legal channels existed for the online media services providers, for example in the event of cyber attacks, so that they are able to contact the competent authority, so that the latter can take the steps necessary to obtain that information from the internet service provider and to bring criminal proceedings.

The EEA currently collects CO₂ g/km type approval (TA) data for individual LDVs as collated by Member States, in accordance with Regulation (EC) No 443/2009. This includes the VIN and the vehicle's CO₂ value. The VIN are however not published. EEA recent legal assessment concluded that the data does not constitute personal data in GDPR purposes in the hands of the EEA, as the EEA would not be able to link the VIN data to the owner of the vehicle.

Where however the data on CO₂ g/km for individual LDVs qualifies as personal data, Regulation (EC) No 443/2009 is considered by the EEA to provide a legal basis for the processing.

Fleet managers

Fleet managers could include fleets of taxis, rental and lease companies, company cars etc. The use of these vehicles could vary, it is however likely that there are occasions where there is only one individual that uses the particular vehicle, therefore the fleet managers could link the VIN and the fuel consumption/ distance travelled information to an individual vehicle user. The data could in this case become personal data in the hands of the fleet manager.

4.3 Lawfulness of processing personal data

Where the GDPR is considered applicable, any processing of personal data would need to be lawful (Article 5(1)(a)). Consequently, the lawful basis for collecting and using personal data needs to be established. The GDPR stipulates six bases for processing of personal data (Article 6(1))¹⁷:

- a. **Consent:** the data subject has given consent to the processing of his or her personal data for one or more specific purposes.

Article 29 Working Party guidelines on consent¹⁸ provide that consent "*can only be an appropriate lawful basis if a data subject is offered control and is offered a genuine choice with regard to accepting or declining the terms offered or declining them without detriment*". (EC, 2017)

¹⁷ There are additional requirements for processing of special categories of data (GDPR Article 9). These are not relevant to the current study.

¹⁸ The Guidelines were endorsed by the European Data Protection Board in its first plenary meeting.

While the Guidelines further state that “*it is unlikely that public authorities can rely on consent for processing as whenever the controller is a public authority, there is often a clear imbalance of power in the relationship between the controller and data subject.*”, relying on consent by public authorities is not totally excluded. Consent can still be appropriate in certain circumstances, where it is demonstrated that giving consent is entirely optional and there is no real risk of adverse consequences for failing to give consent. Genuine consent should put individuals in charge and offer them real choice and control.¹⁹

However, it would need to keep in mind that there may be owners that will not provide consent to processing of their personal data, also consent can be withdrawn at any time (Article 7(3)).

This could lead to uncertainty in the likely take-up rates (participation levels) of the data collection exercise. Also, if a vehicle changes ownership, the new owner would have to consent regarding the exchange of data, making gaining the consent more difficult for the OTA options. For some options however, such as for the sampling of fleets, gaining/maintaining consent may be considered to be easier than for other options considered, due to the smaller vehicle sample size.

Conversations with OEMs have highlighted several potential limitations with relying on the consent-driven model of data collection, including:

- Will not be able to ensure 100% collection as not all vehicle owners will give consent/ consent is not sufficient to pass on the required information
- Consent will have to be sought on every occasion that data is requested (in case the vehicle owner has changed).
- There is a need to ensure that owners know what they are consenting to. Consent has to be “freely given, specific, informed and unambiguous”, so the consenter needs to be informed about what they are giving consent for and how the data will be used.

- b. **Contract:** processing is necessary for the performance of a contract to which the data subject is party or in order to take steps at the request of the data subject prior to entering into a contract.

This is an unlikely basis for processing of fuel consumption data. Even though a contract between a person and data controller might exist (for example, in the case of OEMs, a sales contract, or in the case of fleet operators, a rental/lease agreement), processing of the real-world fuel consumption data would not be deemed necessary for data controllers to comply with their obligations under the sales contract.

The fuel consumption and distance travelled data, combined with VIN have been collected by OEMs in the scope of fulfilment of services to the customer, for example to provide advice on driving efficiency (see further Section 6). Although some personal data will need to be processed for performance of the sales/rental contract, fuel consumption analysis would be outside this and the customer provides their consent to data processing when they sign the services contract with the OEM.

- c. **Legal obligation:** processing is necessary for compliance with a legal obligation to which the controller is subject.

¹⁹ UK Information Commissioner's Office Guide to the General Data Protection Regulation (GDPR), available at: <https://ico.org.uk/for-organisations/guide-to-data-protection/guide-to-the-general-data-protection-regulation-gdpr/lawful-basis-for-processing/consent/>

The basis for processing can be laid down by either Union law or Member State law to which the controller is subject.

Article 6(3) of the GDPR lays down conditions for the legal basis: “*The purpose of the processing **shall be** [emphasis added] determined in that legal basis That legal basis **may** [emphasis added] contain specific provisions to adapt the application of rules of this Regulation, inter alia: the general conditions governing the lawfulness of processing by the controller; the types of data which are subject to the processing; the data subjects concerned; the entities to, and the purposes for which, the personal data may be disclosed; the purpose limitation; storage periods; and processing operations and processing procedures, including measures to ensure lawful and fair processing such as those for other specific processing situations as provided for in Chapter IX. The Union or the Member State law shall meet an objective of public interest and be proportionate to the legitimate aim pursued.*”

As noted above in section 4.2, Article 12(1) of Regulation (EU) No 2019/631 instructs the Commission to monitor and assess the real-world representativeness of the CO₂ emissions and fuel or energy consumption values determined pursuant to Regulation (EC) No 715/2007. For this purpose, the Commission will regularly collect data on the real-world CO₂ emissions and fuel or energy consumed of passenger cars and light commercial vehicles using on-board fuel and/or energy consumption monitoring devices, starting with new passenger cars and new light commercial vehicles registered in 2021. According to Article 12(2) of the same Regulation, the Commission shall ensure that VIN, fuel consumption and distance travelled data are made available at regular intervals to it, from manufacturers, national authorities or through direct data transfer from vehicles, as the case may be.

The Regulation provides the purpose for processing fuel consumed/ distance travelled data together with VIN, and therefore could provide the necessary legal basis for the processing of the data. The Regulation however leaves it open whether it is OEMs or national authorities that provide the data to the Commission, or if the data is to be collected through direct data transfer from vehicles. The duties of OEMs and national authorities should be specified.

The data collection would also need to comply with other fundamental principles of data protection, as discussed in section 4.5, including the data minimisation principle, according to which only the minimum amount of personal data should be collected that is needed for the purpose.

- d. **Vital interests:** processing is necessary in order to protect the vital interests of the data subject or of another natural person.

According to Recital 46 of the GDPR, the basis is intended to cover only interests that are essential for someone's life, therefore this is not a relevant legal basis for processing real-world fuel consumption data.

- e. **Public task:** processing is necessary for the performance of a task carried out in the public interest or in the exercise of official authority vested in the controller.

The specific task that is in the public interest or the official authority that is being exercised needs to be laid down by either Union law or Member State law to which the controller is subject.

Article 29 Working Party Opinion 06/2014 provides that “*Article 7(e) covers two situations and is relevant both to the public and the private sector. First, it covers situations where the controller itself has an official authority or a public interest task (but not necessarily also a legal obligation to process data) and the processing is necessary for exercising that authority or performing that task. ... Second, Article 7(e) also covers situations where the controller does*

not have an official authority, but is requested by a third party having such authority to disclose data.” (EC, 2014)

- f. **Legitimate interest:** processing is necessary for the purposes of the legitimate interests pursued by the controller or by a third party (legitimate business reasons), except where such interests are overridden by the interests or fundamental rights and freedoms of the data subject which require protection of personal data, in particular where the data subject is a child.

It follows that for the justification, the data controller needs to undertake an assessment as to whether or not the legitimate interests are overridden by the interests or rights of the data subject (proportionality test).

The legal basis shall not apply to processing carried out by public authorities in the performance of their tasks. The basis is also not included in Regulation (EU) No 2018/1725 for the Commission.

These six bases for processing of personal data are set out in Table 4-1.

Table 4-1 Possible lawful basis for policy options under consideration.

Entity/ Stage	Role	Possible lawful basis	Comment
Option A – OTA			
Transfer to OEM	OEM is data controller for this stage	Legal obligation, or Consent	Legal obligation if requirement for all data to be transferred is required by law. Consent if transfer of all data is not required by law. Anticipate only some registered owners will consent for personal data to be processed. Options for seeking consent for OTA transfer would need to be considered for every new owner of the vehicle.
Transfer to EC	OEM is data controller for this stage	Legal obligation, Public task, or Consent	<i>As above, plus:</i> Public task, if this is covered by a general requirement in law, but the precise data required is not specified in law.
Analysis by EC	EC is data controller for this stage	Public task	EC 2018/1725 only applies if data has not been anonymised by OEM
Option B – PTI			
Transfer to PTI station	PTI station is data controller for this stage	Legal obligation, Public task, or Consent	Legal obligation if requirement for all data to be transferred is required by law. Public task, if this is covered by a general requirement in law, but the precise data required is not specified in law – and PTI station is acting for MS authority. Consent if transfer of all data is not required by law. Anticipate only some registered owners will consent for personal data to be processed.
Transfer to MS authority	PTI station is data controller for this step	Legal obligation, Public task, or Consent	As above GDPR only applies if data has not been anonymised by PTI station
Transfer to EC	MS authority is data controller for this stage	Legal obligation, Public task, or Consent	As above GDPR only applies if data has not been anonymised by PTI station or MS authority
Analysis by EC	EC is data controller for this stage	Public task	EC 2018/1725 only applies if data has not been anonymised by PTI or MS authority
Option C3 – EC oversee ad hoc sampling (information provided by fleet managers)			
Transfer to fleet managers	Fleet managers are data controllers for this stage	Legal obligation, or Consent	Legal obligation if requirement for all data to be transferred is required by law. Consent if transfer of all data is not required by law. Anticipate only some registered owners will consent for personal data to be processed. EC to specify sampling required.
Transfer to EC	Fleet managers are data controllers for this stage	As above	As above
Analysis by EC	EC is data controller for this stage	Public task	EC 2018/1725 only applies if data has not been anonymised by fleet manager

4.4 Anonymisation

Even though data can initially qualify as personal data, it can lose this qualification by anonymisation. According to recital 26 of the GDPR, the principles of data protection should not apply to personal data rendered anonymous in such a manner that the data subject is not or no longer identifiable. Therefore, where vehicle fuel consumption information is anonymised so that the data subject can no longer be identified, GDPR provisions no longer apply. Anonymising data so that an individual can no longer be identified, wherever possible, is therefore encouraged²⁰ and desirable (ICO, 2012). It is our understanding that a full VIN can be related to and contribute to identification of an individual. Anonymisation of the fuel consumption data would require removal or anonymisation of VIN information.

The OEMs however suggest that where the data is transmitted from a vehicle OTA, it would necessarily contain the VIN since this is an identifier that vehicle manufacturers commonly use for transferring vehicle data off-board to their own server, or, hypothetically, a Commission server. It is therefore only when the data has been processed on the server and the VIN has been removed, the data becomes anonymous. Therefore, in the first instance where the data is transmitted OTA to OEMs or Member States, VIN will be identifiable and as such the GDPR provisions apply.

4.5 Other fundamental privacy principles

In addition to the requirement for lawful basis, other fundamental data privacy principles for processing personal data apply as well (Article 5 of the GDPR), with which the data controller is responsible for demonstrating compliance ('accountability'). These are the principles of lawfulness, fairness and transparency (Article 5(1)(a)), purpose limitation (Article 5(1)(b)), data minimisation (Article 5(1)(c)), accuracy (Article 5(1)(d)), storage limitation (Article 5(1)(e)) and integrity and confidentiality (Article 5(1)(f)).

4.5.1 Lawfulness, fairness and transparency

This principle combines several aspects: a valid lawful basis would need to be identified for processing (see further discussion in section 4.3) and data processing needs to be in accordance with legislation; processing needs to be fair, so processing cannot be *unduly detrimental, unexpected or misleading to the individuals concerned*²¹; and processing need to be transparent, so the data controller must be *clear, open and honest with people from the start*²² of processing about how their data will be used.

4.5.2 Purpose limitation

According to the principle, the data controller needs to specify the purpose for collecting and processing the personal data. The data need to be collected for this purpose and not further processed in a way that is incompatible with the purpose. Also, most lawful bases require processing to be 'necessary' for the purpose i.e. if the same purpose can reasonably be achieved without the processing, the legal basis does not apply.²³

²⁰ UK Information Commissioner's Office Guide to the General Data Protection Regulation (GDPR), available at: <https://ico.org.uk/for-organisations/guide-to-data-protection/guide-to-the-general-data-protection-regulation-gdpr/what-is-personal-data/what-is-personal-data/>

²¹ UK Information Commissioner's Office Guide to the General Data Protection Regulation (GDPR), available at: <https://ico.org.uk/for-organisations/guide-to-data-protection/guide-to-the-general-data-protection-regulation-gdpr/principles/lawfulness-fairness-and-transparency/>

²² Ibid

²³ UK Information Commissioner's Office (ICO), Guide to the General Data Protection Regulation (GDPR), available at: <https://ico.org.uk/for-organisations/guide-to-data-protection/guide-to-the-general-data-protection-regulation-gdpr/lawful-basis-for-processing/>

Regulation (EU) 2019/631 provides the Commission with the following task: “to monitor and assess the real-world representativeness of the CO₂ emissions and fuel or energy consumption values determined pursuant to Regulation (EC) No 715/2007.” This provides a purpose for processing.

4.5.3 Data minimisation

According to the principle, the personal data shall be adequate, relevant and limited to what is necessary in relation to the purpose for which they are processed. The data controller therefore needs to identify the minimum amount of personal data needed for the purpose and no more information should be held.

This will be a relevant consideration for deciding the scope of the information collected. It is important to determine the minimal data that is necessary to assess the real-world representativeness of the emissions determined during type approval, and no further information should be held. To this end, Section 5 describe the types of analyses that could be conducted depending on the data collected.

4.5.4 Accuracy

According to the principle, personal data need to be accurate and, where necessary, kept up to date. The GDPR does not define what is ‘accurate’, however the UK ICO quotes the UK Data Protection Act (2018) definition that ‘inaccurate’ means ‘*incorrect or misleading as to any matter of fact*’ and goes on to note that ‘*It will usually be obvious whether personal data is accurate.*’²⁴ The UK ICO explains that when the information needs to be updated depends on the circumstances and what the personal data is used for, thus: ‘*If you use the information for a purpose that relies on it remaining current, you should keep it up to date.*’²⁵

4.5.5 Storage limitation

According to the requirement, personal data needs to be kept in a form which permits identification of data subjects for no longer than is necessary for the purposes for which the personal data are processed. Therefore the data cannot be kept for longer than is needed for the specified purposes.

4.5.6 Integrity and confidentiality

This requirement relates to security and requires personal data to be processed in a manner that ensures appropriate security of the personal data, including protection against unauthorised or unlawful processing and against accidental loss, destruction or damage, using appropriate technical or organisational measures. Therefore, the data controllers and processors would need to ensure that there are appropriate security measures in place to protect personal data.

4.6 Some other considerations

In addition to the considerations above on what is personal data, lawfulness of processing, anonymisation and other principles for processing personal data, a number of other important issues should be taken into consideration at an early stage. These include:

- Data protection by design and by default (Article 25 of GDPR), requiring that the controller implements measures designed to implement data-protection principles both at the time of determining the means for processing and at the time of processing
- Considering the extent to which Article 22 of GDPR applies – relating to automated individual decision-making, including profiling

²⁴ UK Information Commissioner's Office (ICO), Guide to the General Data Protection Regulation (GDPR), available at: <https://ico.org.uk/for-organisations/guide-to-data-protection/guide-to-the-general-data-protection-regulation-gdpr/principles/accuracy/>

²⁵ Ibid.

- Security of the processing system (Article 32 of GDPR), requiring implementation of appropriate technical and organisational measures to ensure a level of security appropriate to the risk for the rights and freedoms of the data subjects
- Considering and, if required, undertaking a data protection impact assessment (DPIA, Article 35 of GDPR). This is required where the processing is likely to result in a high risk to the rights and freedoms of individuals and this may not be the case with fuel consumption data.

As the European Commission has been given the mandate for the collection of OBFCM data, including the VIN, through the Regulation (EU) 2019/631, then for the development of the implementing acts for the specific means to collect the OBFCM data, the Commission will need to:

- consult with the European Data Protection Supervisor (EDPS) to ensure there are no issues that may contravene the GDPR, particularly with respect to collection of personal data.
- liaise with the European Data Protection Board (EDPB) which is EU body that ensures consistent application of data protection issues across the EU. It is made up of the Member State representatives responsible for data protection issues.
- ensure that any data collected and stored is anonymised so that it cannot be linked back to individual people. Where VIN data is collected, this would need to be stored in such a way that it cannot be readily linked back to the vehicle keeper, and preferably aggregated. Aggregation would be difficult, particularly if data is sent directly OTA to the EC or EEA. This would initially need to be stored in a non-aggregated form in order to allow OEMs to review in a data repository.

5 Data analysis considerations

5.1 Introduction

This chapter explores the various considerations that should be made when collecting and assessing the OBFCM data, regardless of the reporting method. It is also important to understand what can be analysed based on the type, quantity and quality of data gathered and made available to the Commission. Therefore, this section also reflects on what additional parameters could be usefully recorded and/or collected, in particular average vehicle speed.

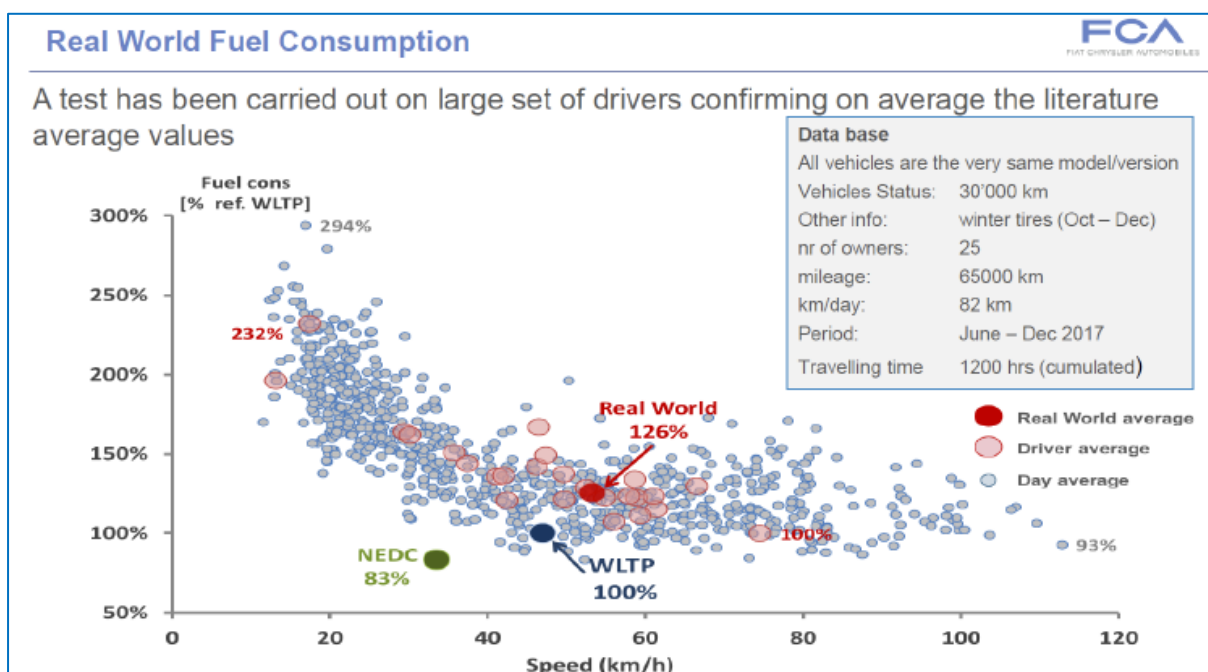
5.2 Analysing the real-world fuel consumption data

The main purpose of the data collection activity is to compare the real-world data with the TA values in a meaningful way, to identify any divergence between the two datasets, and how this evolves over time.

5.2.1 Variation in real world-fuel consumption

A concern that has been expressed by some stakeholders is the ability to draw accurate and meaningful conclusions from the real-world data using the currently defined OBFCM parameters. The fuel consumption of vehicles is heavily influenced not only by the vehicle itself, but also by variations in driving habits and driving conditions, and so the same vehicle can show varying levels of fuel consumption. Figure 5-1 shows analysis by Fiat Chrysler Automobiles (FCA) on the variation in real-world fuel consumption data for nominally identical vehicles, where the *daily* trip averages range significantly from 93% to 294% of the WLTP reference value (100%). Ligterink & Smokers (2016) also reported a typical variation of +/- 15 g/km between vehicles in the same type approval CO₂ segment.

Figure 5-1: Variation in real world fuel consumption data for nominally identical vehicles, driven by 25 different drivers each carrying out multiple trips (source: FCA, 2018)



The factors that influence fuel consumption on the road include:

- Vehicle characteristics (e.g. vehicle load and fuel type)

- The use of auxiliary systems fitted to the vehicle
- Vehicle maintenance and ageing
- External factors (e.g. climate, weather, altitude, road conditions and traffic conditions)
- Driver factors (e.g. driving style)
- Trip characteristics (e.g. vehicle speed, trip length and grade)

A further complication is that the influence of these factors can change over time, and on average they can vary by Member State, vehicle manufacturer and vehicle type. Each factor is discussed in more detail in Appendix D.

5.2.2 The importance of data averaging

An effective way of reducing the data variability outlined in the preceding section is by data averaging. Figure 5-1 showed an example where the *daily* trip averages range from 93% to 294% of the WLTP reference value (100%) – the maximum is a factor of 3.16 times the minimum. However, for the driver average over the *6-month* period, the range of variations away from the reference is reduced to 100% to 232% - the maximum is a factor of 2.32 times the minimum. It is expected that further reduction in variability would be seen over annual/lifetime values (i.e. the OBFCM data), although no direct evidence was found to support this.

Fuel consumption is affected by the ambient temperature, which varies by season. Averaging fuel consumption data over a whole year removes the seasonal variation in fuel consumption.

Figure 5-1 also indicates that the variation in fuel consumption is principally determined by variations in average speed, as discussed further in Section 5.2.3. Different vehicles are used in different ways, with some principally being used for lower speed city driving, whereas others will be used for longer runs on trunk roads at higher speeds. Therefore, lifetime vehicle averages will be likely to still show speed variability between vehicles. Averaging over many vehicles within segments or at the national level may remove this variability. However, this variability may remain at the OEM level if fleet compositions are weighted towards lower-speed 'urban' vehicles or higher-speed vehicles.

5.2.3 Additional parameter: average speed

The lifetime fuel consumed, and distance travelled parameters, allow the fuel consumption to be calculated as a metric of litres per kilometre (l/km).

Variation in average vehicle speed strongly determines variation in fuel consumption (as shown in Figure 5-1).

Average vehicle speed differs between city and motorway driving, and the share of these driving operations may differ between fleets of vehicle manufacturers and Member States. For example, some vehicle models are designed and purchased as city cars, while others are designed for longer journeys at higher average speeds. Vehicle speeds can also reflect driving styles, which can be influenced by the type of vehicle.

As well as helping to understand the drivers of any trends observed, data on the average speed could support the assessment of how well the WLTP reflects real world driving conditions. This could be achieved either by directly collecting vehicle speed data or data on the accumulated engine run time.

In the US, CARB's OBD regulation for light-duty vehicles includes a requirement for vehicle operation tracking (CARB, 2016). As well as total distance travelled, and fuel consumed, the cumulative time spent in idle, city, and highway operation is collected. The breakpoint for city and highway is defined as 60 km/hr, which is a low enough speed that cumulative time spent above it has no value for distinguishing a driver operating at 61 km/hr, 100 km/hr, or even 200 km/hr. This means that it is *not possible to infer driver behaviour* with respect to speed limits.

In line with CARB's conclusions, requiring the collection of average speed or cumulative operating time, is not expected to add any personal data considerations as it not possible to infer vehicle speeds at a specific point in time.

In the CO₂ regulations for LDVs and HDV, there is no explicit requirement to report the average vehicle speed. However, the reporting of *additional* parameters falls under point (f) of paragraph 2 of Article 12, which states "other parameters necessary to ensure that the obligations set out in paragraph 1 of this Article can be met". However, the WLTP 2nd Act for LDVs would need to be updated as it currently lists in full the parameters that should be stored on board the vehicle and made available for collection.

5.2.4 Aggregation and anonymisation

The fuel consumption data collected will be aggregated and anonymised for analysis purposes. This aggregation, and the collection of lifetime fuel consumption rather than for individual trips (as discussed in Section 5.2.2), will normalise many of the influencing factors that are listed in Section 5.2.1, and support the interpretation of real-world fuel consumption and any divergence from the TA value.

The average fuel consumption can either be calculated from summing the distance weighted average of the fuel consumption of the individual vehicles, or from the total amount of fuel consumed divided by the total distance driven by all vehicles. **These two approaches give the same answer.** However, if one used fuel economy (distance driven per unit fuel consumed) the two average fuel economies would be different because of the reciprocal relationship between fuel consumption and fuel economy. The latter approach is the simpler, because it merely involves the direct quotient obtained from the total fuel consumed and total distance travelled for the aggregated group of vehicles.

When aggregating the collected data into a subset of the total vehicle fleet, a representative sample should be an unbiased and accurate reflection of the CO₂ emission and energy consumption characteristics of the entire vehicle population within that sub set. As the **sample size** increases, its representativeness of the population will generally increase as well. Furthermore, a larger sample will reduce the uncertainty and increase the level of confidence in the sample average. A much smaller volume of data can still be considered representative if an effective data selection methodology has been followed, and Section 8 on Ad-hoc Sampling introduces several options for sampling the vehicle population.

The stage at which the data may be aggregated and the organisation responsible, depends on the data flow and storage process, which will differ depending on the reporting option that is chosen.

If the OBFCM data are reported OTA:

- data aggregation and storage of individual records can be carried out by the **OEM** before submitting aggregated data to the EC;
- individual records can be submitted by the OEM to the **Commission or EEA**, who will then aggregate the data and store the original records; or
- individual records can be submitted directly to the **Commission or EEA**, who will then aggregate the data and store the original records.

If the OBFCM data are reported via PTI:

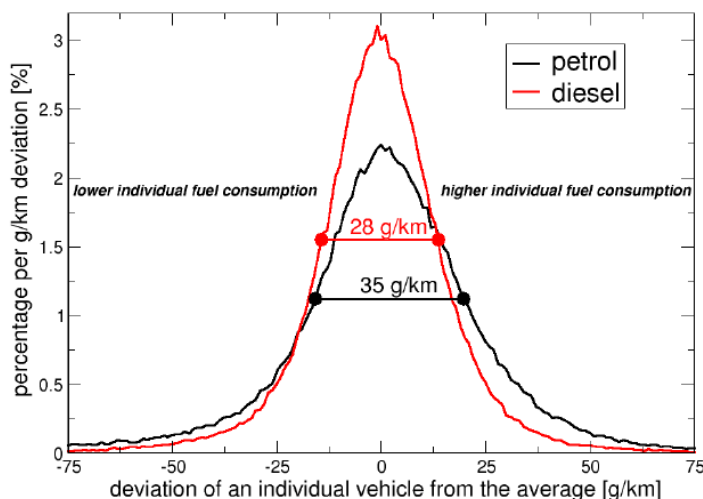
- data aggregation and storage of individual records can be carried out by the **national authority** before submitting aggregated data to the Commission or European Agency; or
- individual records can be submitted by the national authority to the **Commission or EEA**, who will then aggregate the data and store the original records.

Given the effectiveness of technologies applied to reduce vehicle emissions is inherently highly variable, the Commission's objective is to monitor any divergence between the test procedure and the average real-world emissions to enable the effective designing of CO₂ targets. As these targets are applied

across the fleet by vehicle manufacturer, it is important to see if there are systematic trends for particular OEMs, and so data aggregation should be at least at the level of the manufacturer. Further analysis at other levels of aggregation can be undertaken and the accuracy and confidence interval evaluated to guide decisions regarding the optimum level of aggregation, with respect to data representativeness.

When aggregating datasets and calculating an average, the distribution of the data is an important aspect. This is emphasised in pages 22-24 (variations between vehicles and drivers) of the Ligterink & Smokers 2016 report and is shown in the figure below.

Figure 5-2: The variation in real-world CO₂ emissions of individual vehicles (Ligterink & Smokers, 2016)



Rather than looking at maximum and minimum values of the data-set, at the extremes of the distribution curves, TNO use the “full width at half maximum height” (FWHM) measure for characterising the distribution. It is noted this uses the “median” value (the maximum height) not any average. It is also commented that the TNO data shows other potentially important parameters regarding the data analysis:

Whilst the 28 g/km (petrol) and 35 g/km (diesel) are the measure of FWHM, they are not evenly distributed, i.e. do not correspond to ± 14 and ± 17.5 g/km because the two curves have different levels of skewness. The petrol distribution is skewed slightly to the left, whereas the diesel distribution is skewed slightly to the right. **This affects the level of certainty to which the differences can be measured.**

The implications of these illustrative datasets for this study are:

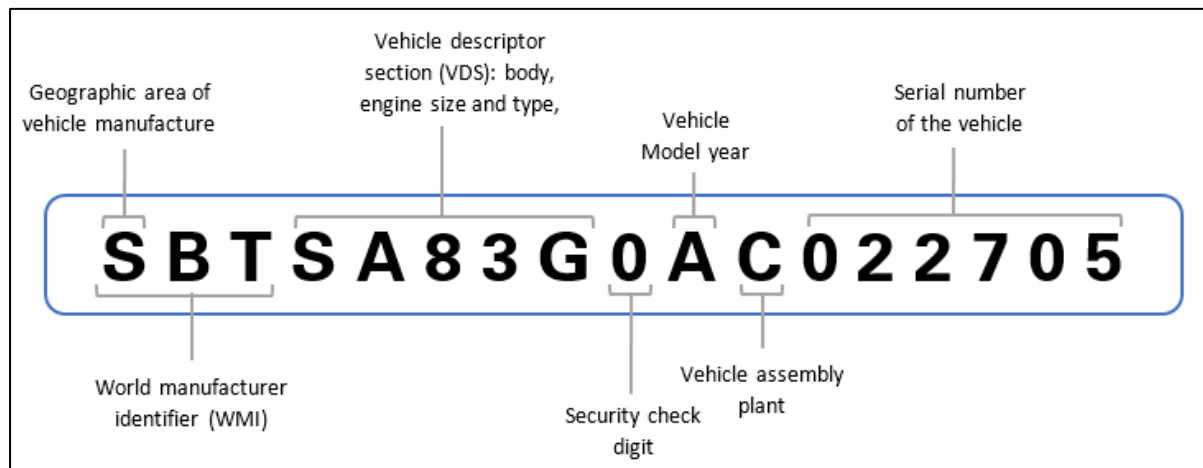
- Until some data has been collected the distribution of the data, in terms of absolute fuel economy, will not be known.
- A useful way of characterising the distribution is using
 - The median value, fuel efficiency that has the highest frequency in the distribution;
 - The full width at half the maximum height of the distribution
 - Its skewness, i.e. how that full width is distributed about the median.

5.2.4.1 Vehicle identification number (VIN)

The key parameter that acts as the vehicle identifier for LDVs and HDVs and allows aggregation at various levels, is the Vehicle Identification Number (VIN). The VIN (see Figure 5-3) is visible in several locations on a vehicle and can be found on related documentation, such as the vehicle insurance policy and registration. It is a unique 17-digit alphanumeric code assigned to vehicles following production and

cannot be changed. It contains information describing and identifying the vehicle and follows a standardised composition that is largely recognised globally. In the EU, Commission Regulation No 19/2011 defines the requirements for the VIN of motor vehicles, referencing ISO standards.

Figure 5-3: Vehicle Identification Number (VIN)



It should be appreciated that some information in the VIN is straightforward to interpret. For example, the 10th character alone identifies the vehicle model year. However, the five-character Vehicle Descriptor Section (VDS) (characters 4 to 8) is encoded and so, for example, the vehicle's fuel type is not simply identified from one of these characters.

Anonymisation

Paragraph 2 of Article 12 in EU regulation 2019/631, states that:

The vehicle identification numbers shall be used only for the purpose of that data processing [creating anonymised and aggregated datasets] and shall not be retained longer than needed for that purpose.

As discussed in Section 4, a challenge of handling VIN is that some consider it a personal identifier, so when VIN is combined with other information it can be personal information. Aggregation of data removes the VIN and anonymises the data such that it can no longer be considered personal data. Another anonymisation approach is to truncate the VIN by removing the final 6 characters (serial number) that identify the individual vehicle.

However, several stakeholders have commented that aggregation for data analysis *should not remove the ability to identify individual vehicle records* (i.e. by VIN). As discussed in more detail in Section 5.3, there needs to be a mechanism for verifying whether a vehicle has reported its OBFCEM data for a reporting period, for tracking vehicles across reporting years to calculate annual values, for identifying the corresponding TA values. Furthermore, without VIN, it would not be possible to carry out spot checks of the data and errors could not be traced.

5.2.4.2 Aggregation options

At the highest level, an average could be taken of all the vehicle data records collected to provide analysis of the real-world representativeness of type approval values at the **EU fleet level**. At the next level, real-world fuel consumption could be interpreted at the **manufacturer level**, by aggregating the real-world fuel consumption data for an individual manufacturer and comparing it with their official average fuel consumption value. A third option is to **further disaggregate** the vehicle fleet within the manufacturer's fleet. For example, fuel consumption data could be assessed by vehicle fuel type,

segment or CO₂ interpolation family (see Box 1). The data could also be aggregated at these levels across the whole EU fleet, rather than within the manufacturer's fleets.

Box 1: Interpolation family

Set of vehicles whose official test CO₂ values fall on an interpolation line specified between test vehicle high (TVH) and test vehicle low (TVL). The individual vehicle value is dependent on its actual mass, aerodynamic resistance, and rolling resistance.

It may also be beneficial to know the Member State that the vehicle is operating in, when analysing the OBFCM data. This can help to account for systematic variation between countries such as fuel quality and aftersales service quality. This information would be readily available if the data was collected from Member States through the PTI process but would not be as easy to determine if the data was reported OTA. A final level of disaggregation that could also be applied (not presented in table below) is by year of registration. Comparing the absolute gap for different vehicle registration years, as well as looking at annual trends for each may help interpret the drivers of changes in the gap over time. The year of registration can be identified from the 10th digit of the VIN.

Table 5-1 presents the various analysis level options and the benefits and challenges of each. For each analysis option, the minimum vehicle identification data required, defined by the VIN characters, is provided.

Table 5-1: Data analysis options

Analysis level	Sub-analysis level	VIN characters needed (Figure 5-3)	Benefit	Challenges / Limitations
EU fleet	-	VIN not required	<ul style="list-style-type: none"> Allows high level monitoring of the performance of the EU vehicle fleet Indication of real-world contribution of EU road transport CO₂ emissions 	<ul style="list-style-type: none"> No insight into CO₂ emissions influencing factors – limits ability to inform remedial action
OEM	-	1-3 (WMI)	<ul style="list-style-type: none"> Insight into relative performance of each OEM vehicle fleet 	<ul style="list-style-type: none"> Loss of discrimination - Limited insight into fuel consumption / CO₂ emissions influencing factors within manufacturer fleet
	By segment	1-8 (WMI & VDS)	<ul style="list-style-type: none"> Insight into relative performance of different vehicle types 	<ul style="list-style-type: none"> But little insight into factors influencing fuel consumption / CO₂ emissions – limits ability to inform remedial action
	By fuel type	1-8 (WMI & VDS)	<ul style="list-style-type: none"> Enables GHG advantages/ impacts of different fuel types to be disaggregated 	<ul style="list-style-type: none"> Will not account for quality of fuel used in vehicle or use of biofuel blends.
	By interpolation family	1-11 (WMI, VDS & model year)	<ul style="list-style-type: none"> Insight into relative performance of different vehicle types/ interpolation families 	<ul style="list-style-type: none"> Slight increase in uncertainty because difference is not from a unique CO₂ value Less useful for consumers as not model specific
By vehicle /individual CO ₂ value (WLTP)	-	Full VIN	<ul style="list-style-type: none"> Could allow identification of vehicles with below-average real-world gap Data could be used to educate individuals on fuel efficiency 	<p>CO₂ Regulations refer to data processing leading to <u>anonymised and aggregated</u> datasets.</p> <ul style="list-style-type: none"> Personal data challenges and commercial implications. Ability to accurately interpret fuel consumption with OBFCM data in the context of annual variability

5.3 Data collection and processing

5.3.1 Data reporting schedule

The data reporting schedule needs to be clearly defined, including the frequency and time period. For LDVs and HDVs, the new CO₂ emission standards state that the Commission shall monitor and report **annually** on how the 'gap' evolves. Therefore, data from vehicles should be reported at least annually so that evolution of the gap can be monitored. Furthermore, seasonal variations, such as seen in Figure 5-1, indicate that a collection frequency of once a year is reasonable. Further discussion on reporting schedules are discussed within Section 6 (OTA) and Section 7 (PTI).

5.3.2 Implementation challenges

For LDVs, the OBFCM parameters to be recorded in the new vehicles were defined in the WLTP 2nd act at the end of 2018. For both LDVs and HDVs, the principal reporting requirements have been set out in the Regulations on the CO₂ emissions performance standards .

Depending on how the detailed procedures to collect and process the OBFCM data from new vehicles will be defined, updates to the technical specifications of new vehicles may be required and this could represent a constraint in collecting the data from all vehicles from 2021.

For the OTA options, the technical requirements for a vehicle to transmit the OBFCM data OTA are outlined in Section 6.3.2.4. This includes OTA capability in the vehicle and the availability of OBFCM data as signals that can be sent to the vehicle's communication module for transmission.

For PTI collection of the data, there are no constraints on the vehicle side as the parameters should be available to an OBD scan tool in all vehicles from 2021 (see Section 7.2.4). There may be a challenge in ensuring that all PTI stations have the correct tool for collecting the data in 2021, but as described in Section 7.2.1, there is already an inherent delay in accessing OBFCM data due to timing of first PTI for LDVs.

5.3.3 Data handling and processing

The reporting of OBFCM data OTA could feasibly collect data from the large number of newly registered vehicles from 2021. Assuming that data is collected annually and the number of newly registered cars and vans in the EU remains constant, there would be around 90 million data records collected in 2026. If individual vehicle records were kept for one year to allow an annual value to be calculated from each consecutive lifetime average collected, in 2026 around 165 million individual records would need to be handled for LDVs alone. For PTIs, the number of LDVs from which data can be collected from is considerably lower but still very large, increasing from 9 million in 2024 to around 30 million in 2026. As HDVs have annual PTIs, the total number of data records that could be collected through OTA or PTIs would be the same – around 2 million data records in 2026. With such large volumes of data, it is important that suitable IT capability is available, and a clear and robust data management system is put in place.

5.3.4 Analysing annual trends

For LDV, the WLTP Regulation requires *lifetime* energy consumption to be recorded and reported for vehicles. Over time, changes in the lifetime average would decrease due to levelling effects and so it would also be beneficial to consider the isolated annual values over time. The data is not required to be reported as annual values by the vehicle although this can be calculated offline following data collection.

Lifetime values collected in a certain year can be interpreted as annual values by subtracting the lifetime values collected the year before, assuming data is collected every 12 months. If the VIN is retained, consecutive lifetime values from individual vehicles for which there is data, can be subtracted from each

other to calculate the annual value by vehicle. If the VIN is not retained, it is still possible to deduce annual values, but only for the aggregated data level. For example, the annual real-world fuel consumption value for a vehicle manufacturer's fleet could be calculated by subtracting the aggregated lifetime average from the lifetime average value of the year before. To be able to calculate a meaningful annual value this way, the aggregate group of data must be consistently derived.

As mentioned in Section 5.2.4.2, it may be beneficial to interpret the annual values by vehicle model year rather than for the aggregated group of vehicle model years, which is not being consistently derived (e.g. each year, an additional sub group of vehicles is being added to the aggregate average).

5.3.5 Comparing with TA values

Once the real-world fuel data collected have been aggregated, they will be compared against TA values to monitor the gap between the two. To make this comparison, the TA values must correspond to the vehicles that make up the aggregated real-world average. This could be carried out at the individual vehicle level – using the full VIN to identify the vehicles TA CO₂ value – or by interpolation family using the VDS and the vehicle model year to identify the vehicle's interpolation family value.

5.3.6 Verification of the OBFCM data

Requirements have been specified in paragraph 4 of Annex XXII in the WLTP 2nd Act on the accuracy of values provided by the OBFCM device for all vehicle manufacturers. Furthermore, instantaneous values of speed, and fuel consumption by the engine (in two units) and by the vehicle as a whole, are available to be collected. These values can be used by a technician on a vehicle by vehicle basis to verify that the two lifetime sets of information (distance travelled & fuel consumed) are being accumulated at the correct rate. Stakeholders highlighted the importance of verifying the accuracy of OBFCM data as there are risks that the data could be manipulated by the vehicle system or during the data reporting process. Spot checks and simulations were also suggested by a stakeholder as ways of verifying the accuracy of the data being collected by the vehicle.

However, other checks may be necessary to assess and maintain the quality of the data collected and the database, respectively. Depending on the data reporting mechanism, it may be necessary for the Commission to use the full VIN to check whether any duplicate records have been submitted in the same reporting period. If data is reported OTA via the OEM, this analysis could be carried out by the OEM, and if the data is reported via PTI, the MS can carry out this check on the dataset. However, if the data is reported OTA direct to the Commission, it would be necessary for the VIN to be retained for the duration of the reporting period, to be able to identify duplicates.

6 Option A: Over-the-air transmission of data

6.1 Overview of Option A and the sub-options assessed

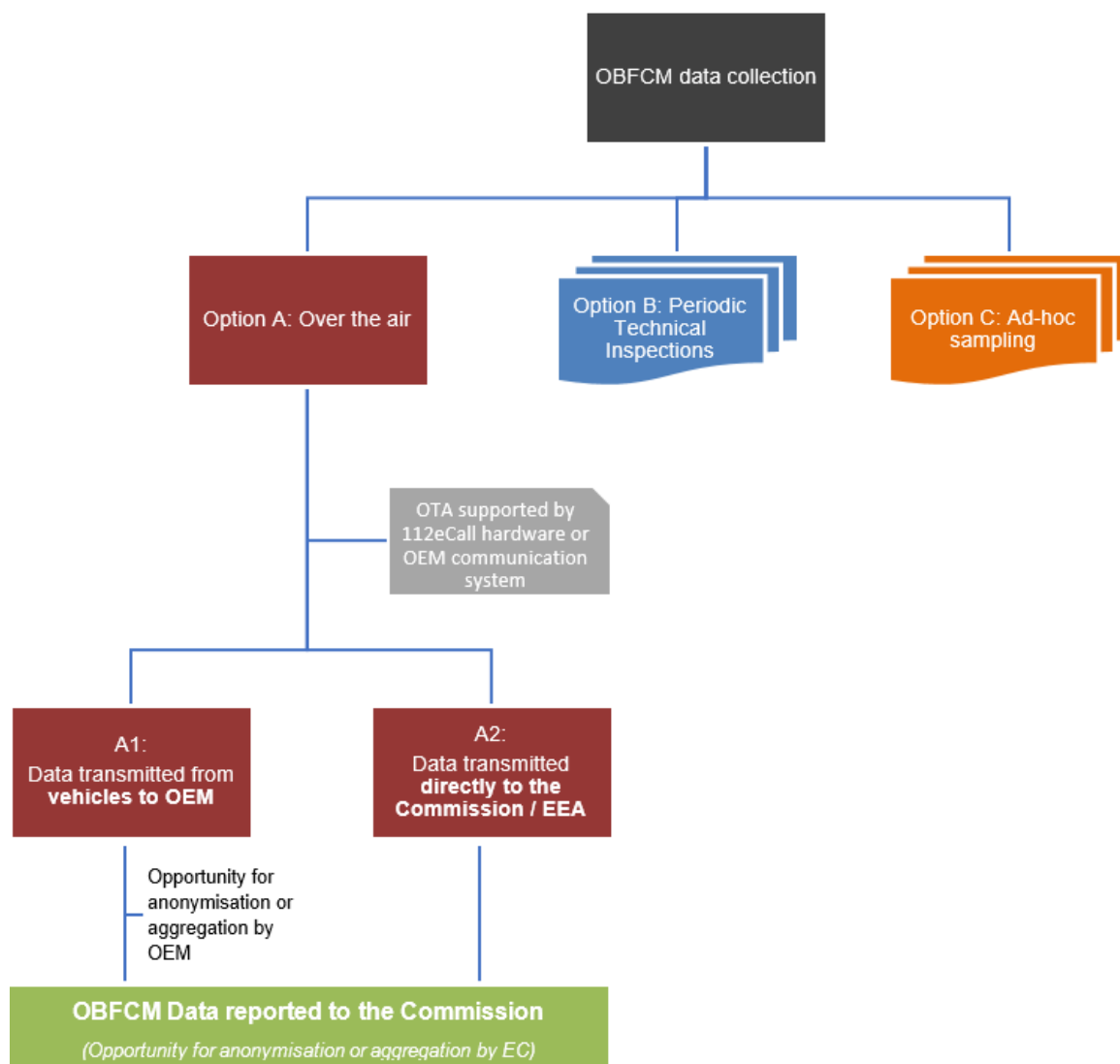
Option A relates to an obligation on vehicle manufacturers to support the collection of the real-world fuel consumption data using over-the-air (OTA) connectivity. As illustrated in Figure 6-1, two versions of Option A were explored:

- **A1** - the reporting of data to the Commission/EEA via the OEM.
- **A2** - the direct transfer of data to the Commission/EEA.

For each option, there is further discussion about the OTA system that could support the data transmission:

- **a** – Using OEM independent OTA system
- **b** – Using the OTA connectively provided by 112 eCall hardware

Figure 6-1: Option A sub-options for OTA data transmission



The legal basis for the data collection is already established by the new Regulation. It has been assumed that for this option, supporting legislation would need to be developed to require action

specifically by OEMs to enable data collection by OTA means. Therefore, a sub-option without supporting legislation has not been considered.

The following sections present analysis on the different OTA sub-options and considerations:

- **Section 6.2** provides background on OTA and discusses elements common to both options, including the data reporting schedule.
- **Section 6.3** covers the transmission of data to the Commission/EEA via the OEM (Option A1).
- **Section 6.4** considers OTA data transmission directly from the vehicle to the Commission/EEA (Option A2).

6.2 Background

6.2.1 Over-the-air technology

Over-the-air (OTA) refers to the transmission and reception of information/data within a wireless internet communication system. In the automotive industry, OTA is used to describe the remote two-way data connection between vehicles and vehicle manufacturer or supplier, via a cloud platform. Cellular communication is the most common form of vehicle OTA connectivity and would be the most appropriate technology in relation to Option A of this study. LTE is the 4G wireless mobile communications standard that operates in the traditional mobile broadband spectrum and would be key to enabling OTA cellular connectivity given its coverage and the plans to phase out 2G and 3G. The emergence of 5G from 2020 will further broaden the cellular communication mix and support the deployment of OTA and connected vehicles. A market outlook report expects the share of connected vehicles in Europe's total vehicle parc to increase from around 17% in 2018 to 50% in 2025 and 73% in 2030 (PwC Strategy & Digital Auto Report, 2018).

Connectivity can be delivered through an embedded modem in the vehicle or by using the driver's smartphone, and is increasingly becoming an essential automotive feature that facilitates a number of services, as listed below:

- eCall
- Remote vehicle updates of software and firmware by vehicle manufacturer
- Transmission of vehicle diagnostics data for service alerts, in-service conformity checks, or customer-centric products
- Monitoring of the vehicle for use by insurance companies and fleet operators
- Enabling a vehicle to communicate safety, mobility or environment-related information with its surroundings (vehicle to vehicle, vehicle to infrastructure etc.) for Cooperative Intelligent Transport Systems (C-ITS) and vehicle automation

The applications that are most relevant to OTA transmission of data pertinent to this study are vehicle diagnostics, telematics and eCall.

6.2.2 HDVs

Operators of heavy duty on- and off-road vehicle fleets have been collecting telematic data for many years. Accessing real time and historic vehicle information, including location and vehicle operation parameters, allows fleet operators to optimise vehicle performance, plan servicing and improve security.

The seven principal European HDV engine manufacturers have agreed to give third parties (e.g. haulage and logistics companies) access to vehicle data via the Fleet Management System (FMS) common interface, which has been designed as an open standard. This allows haulage and logistics companies with a mixed fleet of vehicles to use a single fleet management system. Development of the

FMS-standard is managed by “Heavy Truck Electronic Interface Group”, under ACEA. The manufacturers involved are listed in Table 6-1 and all their vehicles can use the FMS standard.

Table 6-1: Heavy duty vehicle manufacturers involved in the FMS-standard

Vehicle Manufacturer	Bus	Truck
Daimler	✓ (EvoBus GmbH)	✓
MAN	✓ (MAN Truck & Bus AG)	✓ (MAN Truck & Bus AG)
Scania	✓ (Scania CV AB)	✓ (Scania CV AB)
Volvo	✓ (Volvo Bus Corporation)	✓ (Volvo Trucks)
CNH	✓ (CNH IrisBus)	✓ (CNH IVECO)
VDL	✓ (VDL Bus International B.V.)	X
Renault	X	✓ (Renault Trucks)
DAF	X	✓ (DAF Trucks)

A secure and legal solution for the remote download of data from the digital tachograph has also been defined (rFMS v2.1, 2017). Using the remote Fleet Management System (rFMS), it is possible to retrieve vehicle information and positions from the OEM server(s), via an application programme interface (API) over http. Under the ‘vehicle status’ resource, the following relevant parameters are some of the mandatory standard service parameters provided by the API that can be obtained:

- Vehicle identification number (VIN)
- Total fuel the vehicle has used during its lifetime (millilitres)
- Accumulated distance travelled during its operation (metres)

The full vehicle weight (kg) is an optional parameter. Each OEM can decide whether or not they want to implement this information in the API.

6.2.3 Reporting schedule

An advantage of OTA is that data can be collected at any point in time. Indeed, many OEMs collect data from vehicles multiple times a day. This would allow a common reporting period to be defined for all vehicles. For example, OBFCM data could be reported at the end of each calendar year within a set number of days (i.e. between 31st December and 7th January), allowing vehicles temporarily without mobile connectivity to report the data. Alternatively, vehicles could store a record of the OBFCM data locally at a set point in time (i.e. 31st Dec at 23:59) and then subsequently transmit the data when they are able to. A problem with this approach is that a spectrum of usage durations spanning a year would be collected and the removal of seasonal variability would not be guaranteed. For example, if data was collected on 31st Dec 2021, it could include vehicles that were registered in January 2021 (a year old), all the way through to December 2021 (less than a month old). Furthermore, in the second reporting period (i.e. 31st Dec 2022) comparing annual trends at the vehicle level may result in a full year of use being compared with three months of use in the vehicles first year. This becomes less of a limitation as vehicles age.

The OBFCM data could also be transmitted based on vehicle age, rather than a calendar date. For example, data transmission could be triggered at set anniversaries since vehicle registration, such as 6 months or 1 year. This would allow seasonal variation to be controlled, and at minimum it would also allow the first data transmission to take place once the vehicle is considered ‘run-in’. For road load measurement on the road in the UN Global Technical Regulation on WLTP, test vehicles should have

been 'run-in' and driven at least 10,000 km (or 3,000 km at the request of the manufacturer) (United Nations, 2018).

A final consideration is whether the data transmission would be triggered externally or set for pre-determined times within the vehicle system. If the transmission uses the SIM card from the eCall module, an external trigger would not be suitable as the eCall module is in sleep mode and not visible when not in use.

For Option A, annual collection of the lifetime vehicle data would remove the seasonal impacts on fuel consumption and is in line with the requirement in the CO₂ regulation (both LDV and HDV) for the Commission to "...monitor and report annually on how the gap referred to in the first subparagraph evolves...". More frequent data reporting would incur greater data transmission costs and require the handling of much larger volumes of data.

6.3 Option A1: OTA data reporting via OEM

Option A1 involves the reporting of data via the OEM, using (a) the OEM's OTA system or (b) the hardware that supports 112 eCall service, or both. The OEM then makes the data available to the Commission. This option is in line with the 'extended vehicle' concept (see Section 1.3.5), although there would be concerns over the independence and reliability of the data.

6.3.1 Reporting to the European Commission

Both the 'extended vehicle' concept and the FMS provide an interface through which third parties (i.e. the Commission) could securely access the OBFCM data from the OEM server. The Extended Vehicle concept (ISO standard 20078) covers both LDVs and HDVs and provides a market ready approach to safe and secure third-party access to vehicle data. The FMS covers HDVs. Both standards were frequently referenced by the stakeholders who were engaged with.

The use of a neutral server was also suggested. Neutral servers can be set up to collect vehicle data from the OEM server and then make the data available to third parties (i.e. the Commission) without the need to sign a contract with the OEM. They are not operated or financed by the OEM, although security and data protection would still be paramount. A benefit is that neutral servers can collect data from multiple OEM servers, centralising the data protection process.

Before any data can be sent to, or accessed by, the Commission, a lawful basis would need to be established for the data collection, as described in Section 4.3. Secondly, a contract would need to be established between the OEM and the Commission, including Data Processing Agreements, Service Level Agreement, and agreement on commercial aspects such as costs.

There are several options for an OTA reporting schedule, which have been presented in Section 5.3.1.

6.3.2 A1a: Using OEM OTA Availability (excluding eCall hardware connectivity)

6.3.2.1 Degree of OTA connectivity in new vehicles (excluding eCall)

As part of the stakeholder engagement activity, the existing and planned degree of OTA capability (excluding eCall) in new vehicle sales was explored with OEMs. Eight out of the ten LDV OEMs who responded provided data on planned OTA capability by 2021, while five OEMs shared information on current vehicle OTA capability. Three HDV OEMs were consulted; between them, they represent 36% of the N3 vehicle market and 22% of the M3 vehicle market. Aggregated results of the data collected is presented in Table 6-2 below.

Cars

The aggregated results of the data collected for passenger cars are presented in Table 6-2.

Table 6-2: Current and planned degree of OTA capability of OEMs in new car sales (excluding eCall hardware).

Year of OTA capability in new car sales	Respondents share of total EU new car sales	% OTA capability of responding OEMs
2019	32%	30%
2021	47%	90%

All manufacturers responding indicated that they have plans for their vehicles to be connected via OTA (excluding eCall). The share of cars from those OEMs, which are planned to have OTA capability is 90%. Most respondents indicated 100% by 2021, while one OEM indicated it is targeting full OTA in a later year. One OEM was prioritising OTA in certain segments first, but all others indicated that roll out of OTA would be homogeneous across segments. An OEM noted that vehicle price would not be a decisive factor for the priority in the roll-out. Instead, variation in roll out would be determined by new vehicle homologation and planned introduction schedules. It should be considered that OTA capability does not always guarantee that the OEM communication system will be installed in the vehicles. Two OEMs said that the communication module is only installed if the customer chooses to have OTA capability.

No difference was identified in the current or planned OTA capability between PHEVs and conventional vehicles.

LCVs

Three vehicle manufacturers provided information on the degree of OTA in their light commercial vehicles, with two indicating 100% OTA capability by 2021 and one planning 90% capability. No difference in roll-out between N1 and N2 or between the classes of N1 vans was identified.

HDVs

There is currently no OTA capability in any of the M3 vehicle sales of the responding manufacturers, while a larger proportion of their N3 vehicle sales (39%) are equipped with OTA. The manufacturers are expecting, on average, that 12% of new M3 vehicles will have OTA capability in 2021, and that there will be a significant increase in OTA capability for new N3 vehicles to 77% from 2021.

Table 6-3: Current and planned degree of OTA capability in new HDV sales

Category	Year of OTA capability in new vehicle sales	% OTA capability of responding OEMs
Trucks N3	2019	39%
	2021	77%
M3	2019	0%
	2021	12%

6.3.2.2 Storage and transmission of fuel consumption parameters

Cars

The data that is currently stored and transmitted by vehicles varies greatly between OEMs. The VIN and lifetime fuel consumed, distance travelled, and fuel efficiency parameters are often stored in vehicles, but their transmission depends on what the OEM's OTA service is. VIN is available for OTA transmission because of the 112 eCall service and is typically also transmitted for OTA user services, in order to match data that has been processed by the OEM server with the corresponding vehicle.

Total distance travelled is the next most common parameter that is stored and transmitted OTA. One OEM noted that both the distance travelled, and fuel consumed will be reset in their vehicles when a trip meter is initialised, and similarly another OEM said that fuel consumed is only available for the current trip. One OEM highlighted that they store total distance and average fuel consumed in the vehicles, but not according to the J1979 OBD standard.

As required by EU Regulation 2018/1832, all vehicles will store the OBFCM parameters and the majority of OEMs responded that they **could** transmit the parameters OTA from 2021. Whether there are plans to transmit them depends on the services offered, as described above. There is an increase in the number of OEMs planning to transmit some of the parameters as part of plans to introduce OEM OTA services.

However, for OEMs that currently transmit data, there are no significant plans to extend the existing range of parameters. The updates that would be required to extend vehicle OTA capability to include the OBFCM parameters are discussed in Section 6.3.2.4 below.

Several OEMs who were engaged with offer PHEV models. None indicated that they currently transmit PHEV related OBFCM parameters, although from 2021, all of them indicated that they could, and one OEM has plans to transmit the parameters.

LCVs

The trend for LCV is similar to passenger cars. There is variation in what OEMs could currently transmit, with one OEM able to transmit all parameters, and one OEM only able to transmit VIN and fuel efficiency. From 2021, each OEM could transmit all the parameters and one OEM plans to transmit all the parameters.

HDVs

No plans were highlighted by the OEMs to change the current capability of vehicles to store and transmit data. Already, each OEM transmits the VIN, lifetime distance travelled, and fuel consumed. Furthermore, fuel efficiency is calculated by one OEM in the backend, and by one OEM on-board the vehicle, using the fuel rate and mileage to calculate vehicle fuel consumption in litres/100km.

The situation is more varied with the recording and transmitting of average payload. Each OEM is able to estimate the vehicle's Gross Train Weight (GTW). Kerb weight can be subtracted to estimate the payload, but not all OEMs make this calculation. The main challenge is how to estimate the vehicles' kerb weight, as this will change as trailers are added to the truck. Furthermore, it is not always clear whether additional weight should be defined as payload or kerb weight, such as a crane bolted onto the truck.

One of the OEMs estimates the GTW of the truck and trailer through algorithms in the ECUs, which use Newton's third law. This is calculated second-by-second and the information is used by the vehicle's automatic transmission system to select the correct gear to be in at any given point in time. They do not have plans to calculate payload, because the benefits do not outweigh the cost of the dedicated hardware required or the complexity of integrating the system across different manufacturers and into trailers. Another OEM estimates payload from the GTW data collected in the Electronic Braking System.

6.3.2.3 Factors influencing vehicle OTA connectivity of cars

Type of connectivity

Nine out of the ten LDV OEMs who responded currently/plan to use an embedded modem with a SIM card in the vehicle. This system connects to a cellular network to transmit the vehicle data to an OEM data server. One of the OEMs relies on drivers' personal smartphones to transmit data and support the user service. They indicated that this will not change in the near future.

An advantage of relying on a customer's smartphone for data transmission is that smartphones tend to be replaced regularly and will remain compatible with changes in cellular technology. There is a risk that embedded vehicle communication technologies may become outdated if the mobile network operator favours of new network standard that is not supported by the in-vehicle connectivity modules. This could limit the ability of vehicles to transmit data OTA. A solution is for mobile network connectivity standards to be backward compatible. The advantage of a built-in modem is that it gives the vehicle independent OTA capability. Data could be transmitted from the vehicle without any action required from the vehicle operator.

Each of the HDV manufacturers engaged with has a technical solution for the transmission of data, which utilises an on-board device connected to the OEM's backend server via the cellular network.

Enabling OTA connectivity

In the majority of cases, OTA connectivity in vehicles is made available to support a user service. Vehicle data is transmitted to the OEM server, where it is processed and then pushed to the driver's smartphone application or made available through a website for the driver or fleet operator to access. These services can be used to:

- Monitor driving style and improve fuel efficiency
- Book vehicle services
- Monitor the performance of the vehicles
- Access autonomous features such as remote parking assist
- Monitor the location of the vehicle remotely

Most LDV OEMs indicated that the subscription cost is paid by the owner of the vehicle, although sometimes a free subscription is included for several years after purchase. After that, the owner of the vehicle is responsible for renewing the subscription to the service. One LDV OEM indicated that at the end of their free period, about 70% of subscriptions will be renewed. In other cases, the OEM bears the costs of the service and there is no monthly cost for the user. One OEM noted that a one-off lump sum may be charged at point of purchase. It is expected that user subscriptions to the service will reduce under second and third hand owners, although no statistical information was available from OEMs on the magnitude of this decrease.

The other step required to enable OTA capability and transmit the vehicle data is establishing a legal basis, which is usually done through consent or a contract. This can happen in person at the point of sale, or digitally through the services app/website. The legal basis can be lost by OEMs if users withdraw their consent or withdraw from the contract.

As with the situation in cars, the connectivity in HDVs is offered as a part of a commercial service and so the customer must subscribe to the service. The HDV OEMs all highlighted that it would be difficult to guarantee data transmission for the complete history of the vehicle, as connectivity is decided by the owner and an HDV may pass through multiple owners and member states during its lifetime.

Other considerations

Even when a vehicle is able to transmit the OBFCM parameters OTA, there is a possibility that part of the in-vehicle system may break down. A malfunction of hardware or a software failure could impact the data collection, storage or transmission process. In a mandatory data collection scenario, malfunctions that result in the loss of a vehicle's capability to transmit the OBFCM data would need to be defined and addressed in the regulation. No statistical information on failure rates was identified, but it is expected that it would be very low (less than 1% of vehicles). If an OTA data reporting option is selected to collect the OBFCM parameters, it should be considered how to exempt vehicles in cases where OTA devices are no longer functioning. Furthermore, several OEMs noted that there is

uncertainty about what will happen when the networks move to 5G, and how it will impact the ability of existing systems to continue to transmit data OTA.

Furthermore, an OTA-capable vehicle may be prevented from transmitting data if it is operating in a cellular dead zone. This is also expected to be a rare occurrence, with the extensive and growing coverage of cellular networks across Europe and the EU roaming rules allowing the use of cellular networks across Europe at no extra cost. Plans have started to be announced for the switch off of 3G across Europe²⁶. Furthermore, the vehicle only has to have cellular connection briefly during a defined reporting window, or the reporting can just occur at the first possible opportunity.

6.3.2.4 Technical barriers and considerations

As demonstrated in the section above, there is variability in the vehicle market regarding OTA capability. This section considers the technical barriers to OTA transmission of fuel consumption parameters, and the steps that would need to be taken. The considerations can be divided into three:

1. Vehicle systems
2. OEM systems
3. European Commission systems

Vehicle systems

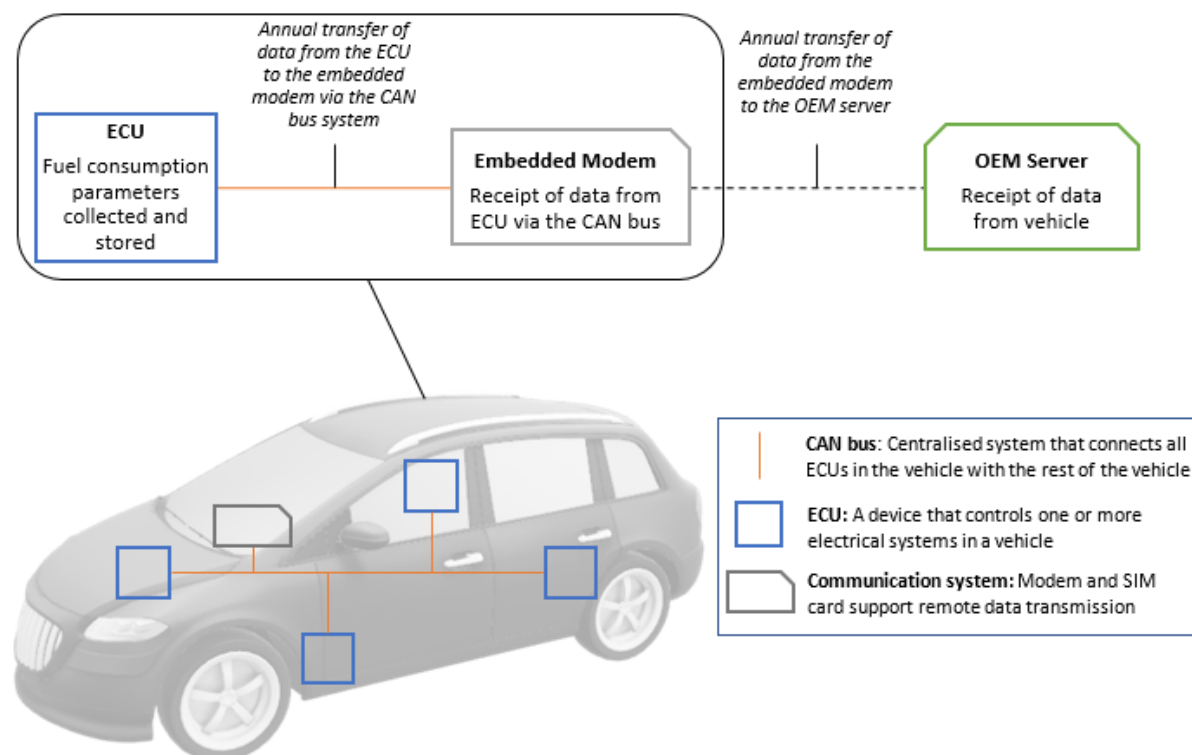
As highlighted in Section 6.3.2.3, one of the LDV OEMs that responded does not have plans to use embedded modems in new vehicles. If this on-board technology was required by legislation, this OEM, and possibly others, would need to design the hardware and software for the on-board modem and integrate the system into new vehicles. For an OEM that has not already invested in an on-board remote communication system outside of eCall, this would represent a significant financial undertaking that may require several years of lead time.

The share of OTA capability delivered by embedded modems (excluding eCall) in new LDV vehicles sales from 2021 is expected to be over 80%, based on the results of OEM engagement which are presented in Section 6.3.2.1. In these vehicles, the necessary hardware exists, and the communication systems have been designed to transmit vehicle data that is required to deliver the OEM's user services. As discussed in Section 6.3.2.2, while most OEMs will likely have the capability to transmit the OBFCM parameters OTA, the parameters are not necessarily part of the designs for the OTA services on offer to vehicle owners. Without updates to in-vehicle systems, vehicles are unable to transmit parameters that were not considered in development of the communication system. The electronic control units that collect and store the OBFCM parameters must be set up to communicate these parameters to the embedded modem, which in turn needs to be able to receive the data and transmit them outside the vehicle (see Figure 6-2:). Furthermore, data transmission is usually triggered by key-in/out or engine on/off events, and so a new longer-term data transmission schedule must be defined. These updates would need to be carried out by the manufacturers' supplier or in-house by the OEM itself.

The updates required in HDVs would be the same as for LDVs.

²⁶ <https://www.mobileworldlive.com/featured-content/top-three/telenor-norway-shut-3g-network-2020-five-years-2g/>

Figure 6-2: OTA communication system (image shows a passenger car, but representative of LCV and HDV)



The full list of software and hardware requirements/updates that may be required are presented below:

- Software update to the Electronic Control Units (ECU), enabling fuel consumption parameters to be available as signals to the vehicle's communication module, via the CAN bus.
- A non-volatile clock in the ECU to ensure information is sent at the right time.
- Crypto-processor hardware in the ECU to prevent unauthorised retrieval of OBFCM data.
 - According to the ICCT, most engine control units (ECU) are already equipped with such a chip, but for manufacturers that do not deploy such a chip, a considerable lead time is to be expected.
- Update to CAN-bus system, allowing the transmission of OBFCM parameters to the vehicle's communication module.
- Updates to the vehicle's communication security protocols, allowing the fuel consumption parameters to be transmitted OTA.
- Update of connectivity settings to set the data transmission schedule.

While the majority of these updates are to software, different hardware may be used in different vehicles and so the OEM needs to understand what software updates need to be developed and in what vehicles they are being deployed.

Payload

Payload has already been listed in the HDV CO₂ regulation as additional parameter compared to LDVs. The impact of load carrying is most relevant for HDVs and the ability to calculate payload is very important for interpreting fuel consumption accurately. From discussions with HDV manufacturers as

part of this study, it is clear that payload is not consistently measured across all vehicles and that there are a number of challenges to estimating payload.

As discussed above, payload can be estimated by subtracting kerb weight from the GTW, but there are challenges with estimating the kerb weight. The trailer kerb weight and trailer axle loads are not always known by the vehicle's OEM, and it is sometimes the responsibility of the customer to record trailer metrics. An OEM commented that the GTW could already be collected remotely from the OEM's data storage by the EC if the accuracy requirements are within the capabilities of existing systems and noting that there would not be complete coverage across the fleet.

Kerb weight can be estimated by:

1. Assuming the trailer combinations according to the VECTO scheme.
In the opinion of one OEM, this would be sufficiently accurate for measuring EU wide fleet averages.
2. Use the low GTW values as a proxy for kerb weight. (i.e. empty truck with no payload)
A more complex calculation algorithm is required for this option to estimate when a trailer is being used.
3. Install communication devices on trailers that communicate the kerb weight of the connected trailers to the truck/tractor.
Trailers would need a dedicated on-board computer with a battery supply for the long periods that they are not connected. This method could be an effective way to accurately calculate the average payload. However, trailers in operation take a long time to replace and currently there are no technical solutions so new standards, protocols and hardware would need to be developed. Furthermore, the external sensors on the trailer or truck body would need calibration on a yearly basis.

Other options for collecting GTW would be through weighing the vehicle on the road or collecting data directly from the vehicles during technical inspections, for which a communication protocol already exists. Some software updates would be required in the vehicles.

OEM systems

If data is reported to the Commission via the OEM, updates would also need to be made to the back-end servers of OEMs to allow them to receive and make the data available to the EC. Other updates may be required, depending on the extent of data processing that needs to take place, such as aggregation.

European Commission / EEA systems

Stakeholders also highlighted that investments would need to be made in the EEA's or Commission's IT systems to ensure they are updated and secure. While each Option would likely require updates and investment in backend systems and servers, Option A may result in a very large dataset, compared to the CO₂ emissions performance values that are currently collected by the EEA. Access to, or synchronisation with, the vehicle registers of national TA authorities would also need to be considered to allow post processing of the data collected.

Member states must submit CO₂ emissions performance values of newly registered vehicles to a Central Data Repository (CDR) once a year. The EEA uses an SQL server to automatically harvest data submitted in CDR, combining the data into one dataset. Fuel consumption data collected from vehicles could be reported to the EC by OEMs using a similar system. Data can also be anonymised by replacing VIN with an ID field. The EEA has not yet considered the possibility of receiving data

directly from vehicles OTA. The Agency has a system in place to obtain real-time air quality data²⁷ from Member States, although the data transmission of fuel consumption parameters from vehicles would not be a continuous stream.

6.3.2.5 Cost and administrative burden

There are a number of costs involved in making data available through OTA, which is why not all data collected from vehicles is made available for OTA transmission by default. However, additional costs are not expected to be significant as much of the infrastructure and hardware is already in place. McCarthy (2017) estimated the costs for an extended vehicle solution to vehicle data access as:

- One-off costs per vehicle manufacturer of €1m - €2.5m
- One-off costs per vehicle of approximately €15
- Annual cost of database €1m - €2m

LDVs

Overall very little information was provided by OEMs on costs. One OEM estimated that the rough cost for them to carry out the necessary updates would be in the single digit million Euros region. Another estimated that the cost to add additional memory for embedded ECUs would be around €15 per vehicle, and if a vehicle model has not been set up for connectivity it would cost around €150 per vehicle. Operational costs of €50,000 per year per vehicle manufacturer was suggested by one OEM. This would comprise of labour costs for operating, servicing and analysing the data as well as the costs for the data transmission to be paid to the cellular network provider. It would be expected that OEMs would seek to recoup costs borne through the vehicle pricing.

It was initially suggested by several OEMs that there would be high data costs linked to transmitting the OBFCM parameters, but upon further discussion it was agreed that the costs would not be significant as the transmission would be infrequent, and the data size is small. Furthermore, one OEM highlighted that they expect to collect and transmit a lot more data in the future, and so they do not see the volume and associated cost as a significant issue of OTA transmission of the OBFCM data. Finally, investment would be required to update the OEM backend server, although no estimates were provided.

Lead times of up to three years were estimated by two OEMs although another OEM estimated one year. This is the time required to develop and implement the updates that would be required in new vehicles for sale.

HDVs

Two OEMs indicated that there would be no extra costs associated with updating their vehicles' systems as they can already transmit the data and the transmission costs would be covered within the driver's subscription. One OEM suggested that there would be initial costs of €300,000 for calibrating the vehicle system and setting up the data reporting for their fleet, while ongoing running costs would be €150,000 per year. The development of a data interface through which the EC could access the data, was also costed at €500,000.

A cost estimate of €2,000 per year was provided for the calibration of load sensing devices. It was noted that fuel consumption is directly estimated by the ECU starting from injector map and other parameters, which is usually within $\pm 5\%$ of the real-world fuel consumption. While a flow meter would improve accuracy to within $\pm 2\%$, it is not recommended due to the high cost of implementation.

²⁷ <http://airindex.eea.europa.eu>

The findings from stakeholder input on costs for LDVs and HDVs vary quite a lot and only come from a limited number of OEMs. Therefore, this evidence is considered not very robust and should be considered a data gap. It is recommended that further evidence should be collected from other OEMs.

6.3.2.6 Summary of strengths and weaknesses of Option A1a

LDVs

+ Vehicles are increasingly becoming 'connected' as OEMs roll out new services and products, and C-ITS and autonomous vehicles progress. Data collected in this study indicates that from 2021, most LDVs will have OTA capability through an OEM independent system (not eCall).

+/- Updates to software, and possibly the hardware, are required in most vehicles to make the data available for OTA transmission. These updates are not considered especially time consuming or expensive.

- Appropriate lead times are required to account for the design and approval process of future vehicle models.

- There is variation between LDVs in what data is transmitted now and, in the future, leading to varying effort required between OEMs to transmit OBFCM data OTA.

- Different OEMs have different business models for their OTA products and services. In some cases, the vehicle owner is responsible for renewing the OTA cellular contract, while in other cases the OEM covers the cost. It is important that OTA connectivity is 'enabled' for the vehicle's lifetime, or for a set period defined by EU regulation and so the cellular contract either needs to be managed by the OEM or paid for upfront for the vehicle's lifetime by the customer.

+ The additional cost of data transmission is very small and would be easily covered within existing cellular contract values.

+ The extended vehicle standard (ISO 20077) is an appropriate solution that standardises the transmission of data to the OEM and access by a third party (the EC).

- Standards need to be reviewed and defined in the regulation and implementing legislation.

HDVs

- There is a lower coverage of OEM OTA systems enabled in HDVs compared to LDVs. There are more aftermarket solutions and so OEM commercial service is not always subscribed to at the point of sale.

+ The majority of HDV OEMs that offer OTA services already transmit the OBFCM parameters.

- There is variation between OEMs in the way that 'payload' is calculated and whether it is transmitted OTA. A standard process should be designed and described in legislation, ensuring consistency in the accuracy in the payload calculation.

6.3.3 A1b: Using the OTA connectivity in vehicle provided by eCall hardware

6.3.3.1 Overview

Since the 31st March 2018, new type approved passenger cars and light commercial vehicles have had the 112-based eCall system installed, as required under Regulation (EU) No 2015/758. The system automatically makes a free 112 emergency call if the vehicle is involved in a serious road accident and it can also be activated manually. It works in all EU countries and will connect the vehicle with the nearest emergency response centre operator. As well as a telephone link, a data link is also activated

to transmit a minimum set of data to the operator. The minimum set of data has a maximum size of 140 bytes and includes parameters such as VIN, location information and a time-stamp.

Similar to OEM independent OTA systems, the majority of new vehicles sold in 2021 will have 112 eCall, but not all will as some older vehicle types may still be sold in 2021 that are not covered under the eCall regulation. As well as a large coverage of new vehicles sold, the eCall system is standardised across vehicles and the OEM manages the cellular contract. This makes it an attractive alternative to transmitting the OBFCM parameters. Therefore, the feasibility of using the SIM card device used to support the eCall service to also support the transmission of the OBFCM data, has been investigated.

HDVs

There is currently no regulation requiring eCall for HDVs, but in the future a similar service may be implemented. Article 12(1) of Regulation (EU) 2015/758 requests the Commission to investigate by 31 March 2021 whether the scope of the eCall regulation should be extended to other categories of vehicles, such as HDVs. Considering the time required for approving a legislative proposal and subsequent transition into vehicles, it is unlikely that eCall for HDVs will be required earlier than 2024.

6.3.3.2 eCall regulation

It is clearly stated in Regulation (EU) 2015/758 that the mandatory requirement for vehicles to be equipped with the 112-based eCall in-vehicle system **should not prevent additional services** being offered, in parallel with or building on the 112-based eCall in-vehicle system. Furthermore, some manufacturers already plan to use the same SIM card that supports eCall for other OTA services offered in vehicles, such as user and telematics services and TPS eCall. This removes the need for having multiple sim cards in the vehicle and negotiating multiple contracts with mobile network operators, although in the event of an incident, the eCall service must have priority.

Co-benefits of using the eCall SIM card for annual OBFCM data transmission could also exist. Annual transmission of the data would provide a mechanism to annually verify that the SIM card is still supporting an eCall service in an active vehicle. National regulatory authorities have raised concerns about the exhaustion of mobile network numbering resources, in part due to a gap in understanding of when a specific eCall device/SIM can be retired. Currently there is no coherent plan for retiring numbers.

6.3.3.3 Technical feasibility

Technically, it is perfectly possible to use the hardware supporting eCall to transmit the OBFCM parameters to the OEM. However, even where the capability for remote communication exists in a vehicle (i.e. modem and SIM card), the design of in-vehicle systems determines what information can be transmitted. Therefore, the updates that would be required to the in-vehicle systems to allow the transmission of data via a SIM card that supports eCall, are the same as those described in Section 6.3.2.4 above. An additional update would be required to the communication system to ensure the SIM card is able to transmit the OBFCM data to a different location compared to the eCall service, which is the emergency operator centre. The SIM cards would also need to be profiled correctly.

The capability to transmit the OBFCM data through the SIM card device used to support the eCall service also depends on the ability of the SIM card to handle additional data transmission, which is governed by the cellular contract between the OEM and network operator. Cellular contracts for the 112 eCall tend to be very low value (e.g. €5 per sim), based on an assumption that there will be very few activations in the lifetime of the vehicle. This considers the fact that airbag deployment tends to write the car off. However, the OBFCM data transmission will be infrequent and unlikely to be above the maximum size of the minimum set of data (140 bytes) and so it should be possible to use the eCall SIM cards without the need of a more expensive contract.

6.3.3.4 Legal feasibility

Stakeholders highlighted that the data transmission of the OBFCM data would have different contractual and legal requirements compared to eCall, and so using the hardware for this other application would need supporting legislation and standards to be developed. The existing eCall standards may also need a change of scope. Guidance and assurance would need to be provided to the OEMs on how eCall hardware can be used.

The data protection considerations are the same as those described in Section 4 above.

6.3.3.5 Summary of strengths and weaknesses of Option A1b

- + There is significant coverage of new vehicles in 2021 with 112 eCall activated.
- + The eCall service is harmonised across all OEMs.
- + The eCall regulation specifies that other services can work in parallel with or build on the 112-based eCall in-vehicle system.
- + The eCall system must work for the duration of the vehicle lifetime
- + Integrating the OBFCM data transfer could provide a solution to retiring eCall numbers
- +/- eCall contracts are very low value, but the additional cost of OBFCM data transfer is also small and so contracts would not be significantly bigger, if at all.
- eCall standards may need updating to change the scope
- Clear guidance and assurance would need to be provided to OEMs on how eCall hardware can be used.

6.4 Option A2: Direct transfer from the vehicle to the European Commission

Another option for OTA data reporting is direct data transmission from the vehicle to a secure platform centrally managed by the Commission or a European agency, such as the EEA. This option is almost identical to Option A1, except that the data is transmitted directly from the vehicle to the EC, rather than via the OEM. As a result, many of the details discussed for Option A1 are also relevant for A2. These are listed below:

- The direct transfer can be supported by either an OEM OTA system, or the SIM card device used to support the eCall service.
- There is expected to be a high coverage of new LDVs in 2021 equipped with both OEM OTA systems and 112 eCall. (see Section 6.3.2.1)
- Not all LDV OEMs currently, or are planning to, store and transmit the OBFCM parameters, and there is variation between OEMs. Most HDV OEMs already transmit the OBFCM parameters (except payload). (see Section 6.3.2.2)
- A number of factors influence whether an OEM OTA system in a vehicle is enabled and active. (see Section 6.3.2.3).
- There are several updates that are required to the in-vehicle system in order for the OBFCM parameters to be made available as signals to the OTA system (the SIM card device used to support eCall service or OEM independent system) and for the system to correctly transmit the data. (see Section 6.3.2.4)

A key advantage of transmitting data directly from the vehicle to the EC, is that it alleviates concerns around the reliability of the data. When data is transmitted via the OEM, there is an opportunity for certain data to be selectively redacted, which may be unknown to the Commission. There is also one less data transmission, possibly improving the data security.

6.4.1 Third-party access to the in-vehicle data

ACEA and vehicle manufacturers support the extended vehicle (ExVe) concept for reasons of data security and vehicle safety, and direct data transmission to the EC would contradict this particular concept. ACEA suggest that for categories of data not defined in the WG6 report (C-ITS Platform, 2015) or for new use-cases, the ExVe standard should be used. The OBFCM data transmission would constitute a new use-case. It is also important to understand that while new use-cases can be defined, developing the ECU software/algorithm to fulfil the use-case is proprietary to the OEM. However, the ExVe concept has not been embraced by all in the automotive industry, namely the aftermarket sector. The European automotive aftermarket federation (FIGIEFA), has rejected the ExVe concept and see *access to the vehicle, its data and functions* in an independent and undistorted way as being key to providing competitive and innovative services. They argue that it increases latency for access by third parties, gives the vehicle manufacturer sole remote access to remote real time vehicle data, hampers independent data collection, and stifles innovation. And while the key argument by OEMs for the need of closed telematics systems (ExVe) is the security of the vehicle, others believe that establishing a safe and secure communication with the vehicle and its data is technically possible. An alternative solution which is supported by FIGIEFA and has been called for by an industry coalition (Direct Access, 2018) is an 'on-board open access telematics platform' (OTP). This is also referenced in the eCall regulation; *"the eCall in-vehicle systems should be based on an interoperable, standardised, secure and open-access platform for possible future in-vehicle applications or services."*

The Commission's Study on 'Access to In-vehicle Data and Resources' (McCarthy, 2017), investigated the different technical solutions to give access to in-vehicle data and found that a future scenario involving the implementation of a harmonised on-board application platform (or interoperable open access telematics platform – OTP) was the only scenario that met the five guiding principles agreed by WG6 in the C-ITS platform (C-ITS Platform, 2015). Furthermore, the study's analysis of the safety and security aspects of an OTP solution was that it is technically feasible, and in their view, there are existing standards and technologies that can be combined and implemented to achieve safety and security. Furthermore, examples of on-board platforms with access to vehicle data already exist:

- General Motor's Next Generation Infotainment Software development kit (NGI SDK) exposes 400 data points from the car for app developer use.
- Smart Device Link (SDL) is an industry standard for open source in-vehicle connectivity, used by a number of OEMs including Toyota and Ford. It connects in-vehicle infotainment systems to applications.
- Apple CarPlay/Google/MirrorLink

It is important to note that vehicle manufacturers still control what data can be made available to an OTP and that the examples above have only limited access to in-vehicle data and are mainly focused on infotainment applications (i.e. not safety critical systems). Furthermore, OEMs will still have to set up the systems on board the vehicles to allow the data transmission to occur.

Another example of an existing solution with a focus on *vehicle operating data* is the Open Telematics Platform (OTP) system. This is an open and non-discriminatory platform for modern telematics services. An OTP backend manages OTP adapters, which are plugged into the OBD-II interface of a vehicle. These adapters read vehicle operating data and then transmits the data to authorised devices or to cloud application via Wi-Fi or cellular, which can be used by applications of telematics providers through an API.

Compared to the extended vehicle solution, implementing an OTP would have higher costs²⁸ as a result of the requirements to develop and maintain in-vehicle hardware. The McCarthy (2017) study estimated that this would require 5 years, including time for development, implementation and validation.

6.4.2 Additional considerations

Transmission via eCall appears to be the most appropriate option for direct transmission. An OEM's independent OTA system has been designed specifically to transmit data to their own off-board servers, and the security protocols in place are based on this flow of data. Furthermore, contracts for OTA services and products that the OEM agrees with customers will also outline who handles the data and who it can be shared with. Therefore, significant updates/redevelopment would need to be made by the OEM to their on- and off-board systems, security protocols and contractual documents. The commission would need to provide a common set of protocols for data transfer that all OEMs can follow. An alternative, albeit extreme, option would be for the Commission to design and provide their own technical solution that can be installed in all vehicles.

Apart from eCall, no standards or technical solutions currently exist for the direct OTA access of vehicle data by a third party, and so a new standard that outlines technical and data protection rules and security protocols would need to be developed. This could hinder the timely implementation of a monitoring system.

Finally, a concern expressed by OEMs was that they should be able to access the raw data in order to detect and correct errors in the dataset and have the opportunity to be able to analyse the data in response to conclusions by the Commission on the real-world representativeness of the fuel consumption of their vehicles have the opportunity to analyse the OBFCM data. The EEA already uses a Business Data Repository (BDR) to provide OEMs with access to a different data set. This approach could be used.

No cost estimates were provided by OEMs.

6.4.3 Summary of strengths and weaknesses of Option A2

LDVs

- + There is significant coverage of new LDVs in 2021 with 112 eCall activated and OEM OTA systems.
- There is a lower coverage of OEM OTA systems enabled in HDVs compared to LDVs, and eCall will not be in new HDV types any earlier than 2024.
- It may not be feasible to use OEM's OTA systems.
- + It alleviates concerns around the reliability of the data by removing the opportunity for data manipulation by OEMs.
- + eCall provides an example of direct data transmission to a party that isn't the OEM.
- + Many in the automotive industry reject the ExVe concept and believe that remote access to in-vehicle data can be safe and secure. Several OEMs already support open platforms providing vehicle data to applications for infotainment.
- There is no current industry wide technical solution or standard for third party access to in-vehicle telematics data (i.e. the OBFCM parameters). These would need to be developed – TRL's study estimated a 5-year lead time for implementing an open telematics platform solution, and estimated higher costs than for a data server solution (i.e. ExVe concept)

²⁸ One-off cost per vehicle manufacturer was the same (€1m - €2.5m), but one-off cost per vehicle was much higher for OTP (€115 vs €15).

- Direct data transmission to the EC would be contradictory to the extended vehicle concept and there is not a common standard or technical solution for the direct OTA access of vehicle data by a third party.

+/- A solution for providing OEMs with access to the raw data would need to be detailed. The EEA already use a Business Data Repository (BDR) to do this for a different data set.

7 Option B: Periodic Technical Inspections

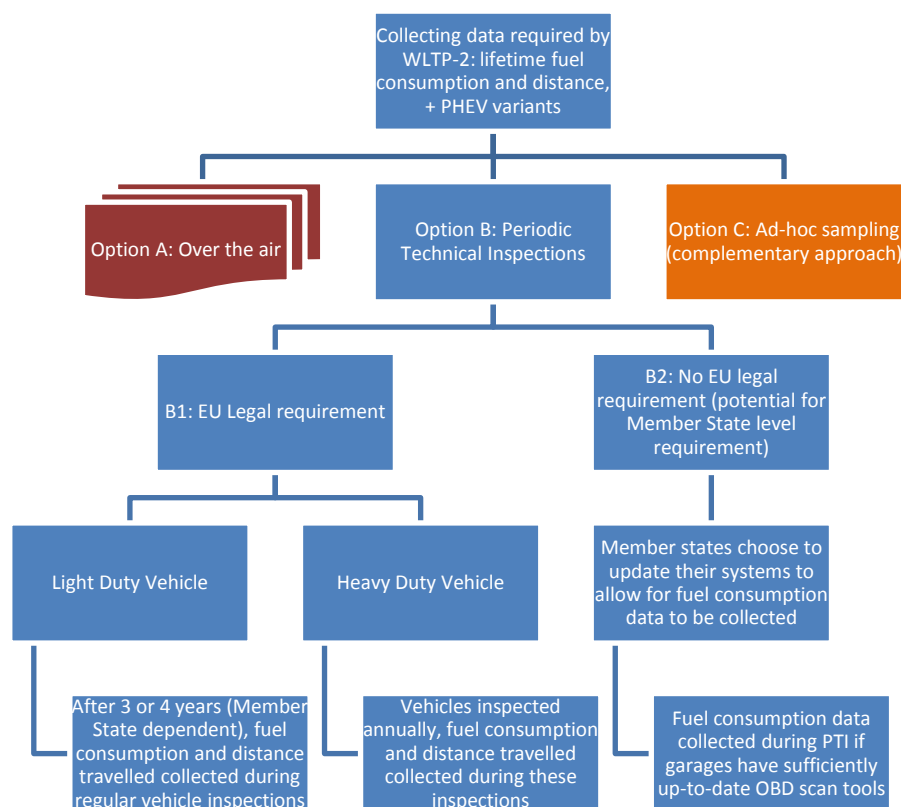
7.1 Overview of Option B and sub-options assessed

Option B proposes collecting fuel consumption information stored in the vehicle during vehicles' periodic technical inspections. This section looks at the possibility, constraints, strengths and weaknesses of collecting information during these periodic inspections. The sub-options considered are shown in Figure 7-1 and are:

- **Option B1:** the collecting of VIN and OBFCM data would be legally required by EU law when a vehicle is brought in for its periodic technical inspection. The required information would be read out by an OBD scan tool, passed to the relevant authority in each Member State for collation and subsequently passed to the European Commission on an annual basis.
- **Option B2:** differs from option B1 in that there would be no EU level requirement for the collection of VIN and OBFCM data during PTIs, but the EU would encourage Member States to set up their own legal requirements to collect the data. This would result in an absence of data from Member States not implementing the requirement, but complete coverage of data for any Member State that does choose to implement a requirement.

Within Option C there is also an option to consider sampling, through collecting data at PTIs, vehicles across the EU with an optional collection of data which may be encouraged through the provision of a monetary incentive. This is discussed as Option C4 in section 8.

Figure 7-1: PTI sub-options



7.2 Background

7.2.1 The Roadworthiness Directive and PTI frequencies across the EU

Roadworthiness checks are carried out at regular intervals on all vehicles registered in the EU. The frequency of the periodic checks depends on the Member State, however the upper limit of the frequency as well as the requirements of the checks conducted are specified in the Roadworthiness Directive (2014/45/EU)²⁹.

Under the Roadworthiness Directive, all N1 and M1 vehicles are required to be presented for inspection, no more than four years after they are initially registered and then every two years subsequently. Member States have the prerogative to set higher frequencies if they wish. Therefore, if data on real world fuel consumption were to be collected at PTIs, no data could be collected until the first PTI which can be up to four years after vehicle registration. For LDVs, the first PTI is three or four years after registration, depending on the Member State. Following the first PTI, subsequent PTIs are every two years in the majority of Member States.

Member States carrying out PTIs at different points in time is one of the key concerns with collecting data through the PTI, as this means that the approaches for collecting real-world fuel consumption data through PTIs will vary according to Member State. This is discussed in more detail in subsequent sections.

Under the Roadworthiness Directive, N1 vehicles have the same testing requirements as passenger cars, initially four years after their registration and then every two years after. Three out of four Member States³⁰ consulted on their national vehicle inspection processes, indicated that they had implemented the same testing requirements for LCVs as for passenger cars (including when the passenger requirements are stricter than the Roadworthiness Directive). Germany has set stricter requirements for LCVs than passenger cars, requiring the first test after two years after registration compared to after three years for passenger cars.

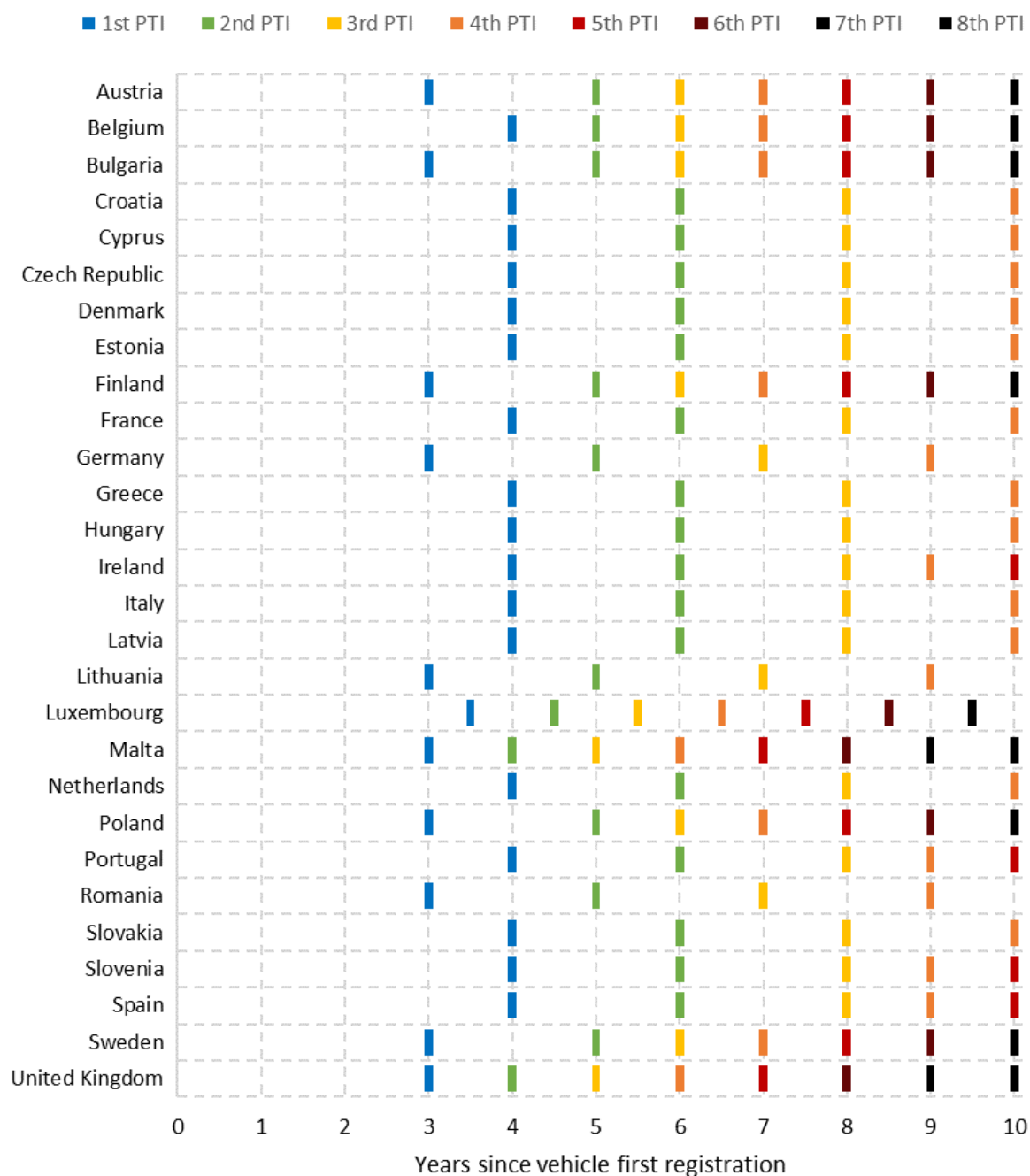
The analysis of LCVs broadly follows that of passenger cars as they have the same testing frequency set out in the Roadworthiness Directive.

For HDVs, PTIs are required every year from the year of registration. Following the first PTI, subsequent PTIs are no more frequent than annually.

Figure 7-2 and Table 7-1 shows how the PTI frequencies vary across Member States for LDVs. They also highlight that while the testing frequencies coalesce around the maximum requirements of the Directive, collecting LDV fuel consumption data through this route would result in a heterogeneous sample. The larger issue, however, is that no data would be collected in the vehicle's initial years on the road until the first PTI has taken place.

²⁹ Directive 2014/45/EU of the European Parliament and the Council of 3 April 2014 on periodic roadworthiness tests for motor vehicles and their trailers and repealing 2009/40/EC

³⁰ France, The Netherlands and the UK

Figure 7-2: PTI frequencies for LDVs in Member States

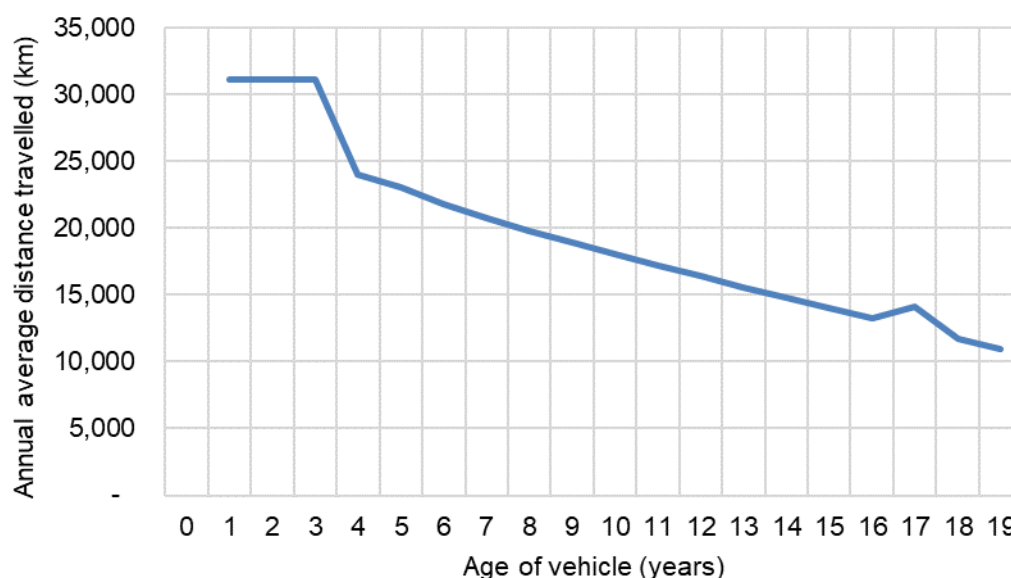
Note: Netherlands is shown for cars other than diesel cars.

Table 7-1: PTI frequencies in Member States for passenger cars*

Member State	Passenger car PTI frequency (years)	Member State	Passenger car PTI frequency (years)
Austria	3-2-1	Italy	4-2-2
Belgium	4-1-1	Latvia	4-2-2
Bulgaria	3-2-1	Lithuania	3-2-2
Croatia	4-2-2	Luxembourg	3.5-1-1
Cyprus	4-2-2	Malta	3-1-1
Czech Republic	4-2-2	Netherlands	4-2-2-1 (3-1-1 for diesel cars)
Denmark	4-2-2	Poland	3-2-1
Estonia	4-2-2-2-1	Portugal	4-2-2-1
Finland	3-2-1	Romania	3-2-2-2-2-1
France	4-2-2	Slovakia	4-2-2
Germany	3-2-2	Slovenia	4-2-2-1
Greece	4-2-2	Spain	4-2-2-1
Hungary	4-2-2	Sweden	3-2-1
Ireland	4-2-2-1	United Kingdom	3-1-1

*The frequency of PTIs implemented in each Member State for passenger cars is represented in the format x-y-z, where x denotes how many years since vehicle registration the first PTI is required, y represents the year from the first PTI to the second PTI, and z denotes the test frequency going forward indefinitely. It is bound by the minimum in the Roadworthiness Directive of 4-2-2.

The gap before a vehicle's first PTI is particularly significant because vehicles are typically driven further when they are newer. Figure 7-3 shows the average annual distances travelled by cars in the UK, collected using PTI data (distance travelled in the first three years is taken as an average of the recording at the first PTI) (Ricardo-AEA, 2015). The results show a significant reduction in annual distances travelled after these three years, highlighting the impact of the time lag from not collecting fuel consumption information prior to the first PTI (and that data separately showing the real world fuel consumption in years 1, 2 and 3 will not be available, but rather as totals for the years 1 to 3).

Figure 7-3: Average annual distances travelled by passenger cars in the UK, disaggregated by vehicle age

7.2.2 Estimating the number of vehicles subject to a PTI each year

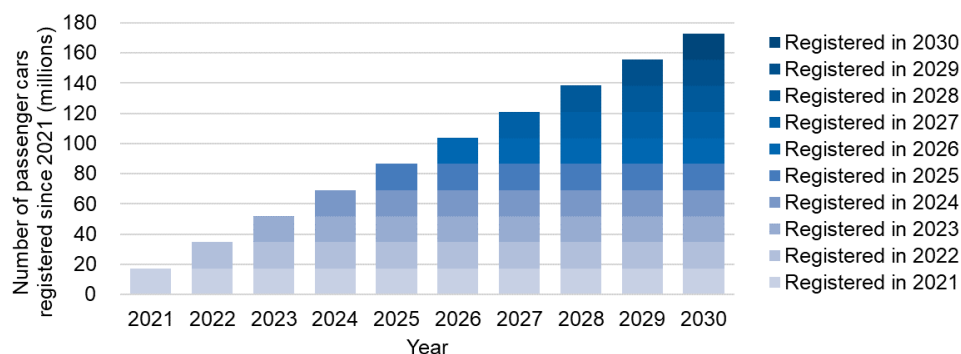
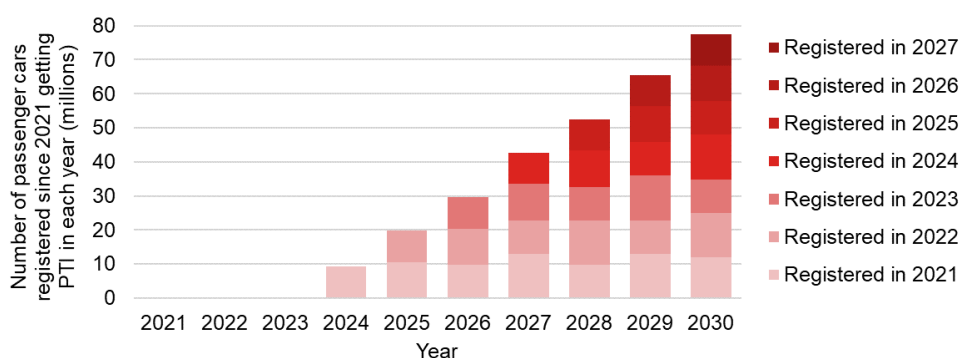
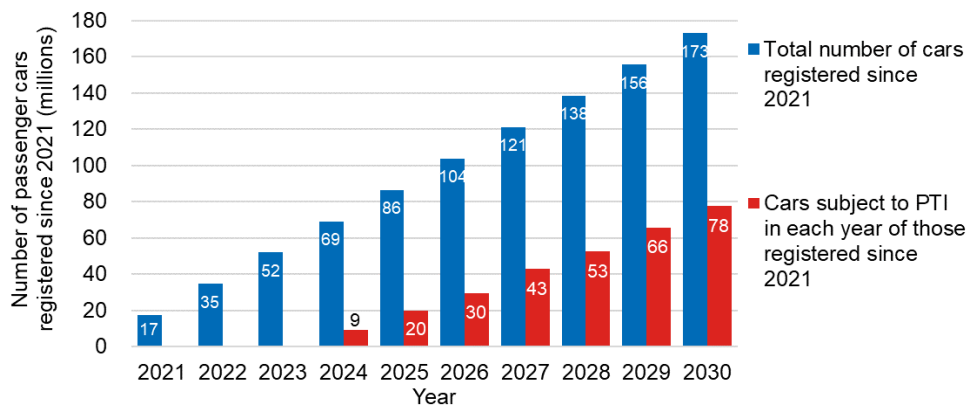
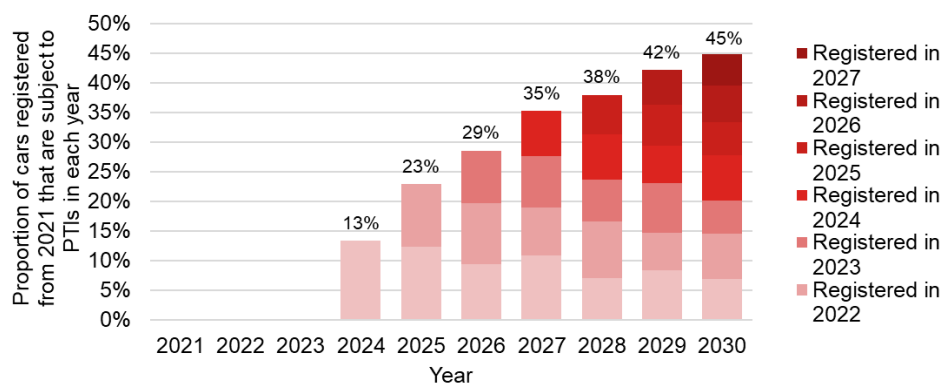
To understand the potential coverage of the fleet, information on the frequencies of PTIs has been combined with data on the number of vehicle registrations per Member State³¹. The figures are calculated by analysing the number of new vehicles registered annually in each Member State and looking at the inspection period in that region (given in Figure 7-2). The data is then used to estimate the number of vehicles inspected each year after the release of the vehicle. This analysis is then repeated for new vehicles released each year. Vehicle numbers are based on 2017 new vehicle registration data per Member State reported in Eurostat (Eurostat - new EU passenger car registrations, 2019) and assumed to be constant in future years. As the period of analysis is limited to 10 years, no vehicles are assumed to be retired from the fleet to simplify the estimation.

The frequencies of PTIs vary by Member State, and notably include gaps for many Member States of two years between the first and second PTIs. This potentially places a limit on the number of vehicles for which fuel consumption information can be extracted in a given year. Nevertheless, the legislated inspection period ensures that data from all vehicles will be available across a two year period, four years after they are first registered.

The estimated number of cars in the EU parc each year, registered from 2021, split by year of registration are shown in Figure 7-4. The estimated number of cars subject to a PTI – at which OBFCM data could be extracted – is shown in Figure 7-5, also split by the year of registration.

Figure 7-6 shows on one graph the totals from Figure 7-4 and Figure 7-5: i.e. the total number of EU passenger cars, registered from 2021, that will receive a PTI between 2021 and 2030 next to the total number of vehicles that have been registered since 2021. Figure 7-7: shows this breakdown as a percentage, highlighting the year that the vehicle was registered in. As discussed, there is a lag in obtaining information from vehicles from 2021 until 2024 or 2025. In 2026, just over 100million cars will have been registered since 2021, of which ~30 million will be subject to a PTI in 2026. Thus the capture rate for understanding the real world fuel consumption of vehicles registered since 2021 in the year 2026 would be nearly 30%. The figure is not higher because (i) some Member States only inspect cars every other year, and (ii) cars registered 2024 onwards will not have received their first PTI yet.

³¹ Assuming all vehicles attend their PTI and all vehicles have their fuel consumption information collected.

Figure 7-4: Estimated number of cars in the EU each year registered from 2021, split by year of registration**Figure 7-5: Estimated number of cars subject to a PTI each year, split by year of registration from 2021****Figure 7-6: Estimated number of cars in the EU and those subject to a PTI each year, registered from 2021****Figure 7-7: Percentage of cars registered from 2021 that are subject to a PTI in a given year**

How well the information collected would represent the entire EU fleet (not just new vehicles) will depend on two factors, the PTI frequency in each country and the vehicle fleet turnover. The annual turnover varies considerably across countries, ranging from 2.1% of the fleet in Greece compared to 12.9% in Luxembourg (Eurostat – passenger cars in the EU, 2019). Assuming the fleet turnover did not change, in Luxembourg it would take 8 years for the entire fleet to have OBFCM installed (and twelve years for fuel consumption information to be collected) and longer for other Member States.

7.2.3 Reporting schedule

The data *collection* schedule for the PTI option is defined by the PTI schedule itself, while data *reporting* can either align to the collection regime or occur at set times (e.g. once per year). PTIs occur throughout the year and so the data would be collected across different time periods (i.e. January to January or March to March). Data could be continually collated by Member States across the year, although reporting to the Commission could then be set for a specific date or dates during the year. As not all LDVs have PTIs every year, following the first PTI it would not be possible to compare the same sample of vehicles in consecutive years, and analysis of annual trends would need to be at the aggregation level rather than at the individual vehicle level.

7.2.4 Accessing data from the on-board device at PTIs

From 2023, the Roadworthiness Directive requires that all PTI stations are compliant with minimum requirements – one of which is ‘a device to connect to the electronic vehicle interface, such as an OBD scan tool’.

The introduction of the Worldwide Harmonized Light Vehicle Testing Procedure (WLTP) requires all new LDVs from 2021 to store and “provide for standardised and unrestricted access” to fuel consumption information within the vehicle, as discussed in section 1.3. This section looks at how this regulation and subsequent standards could be implemented to collect fuel consumption data via PTI, specifically highlighting the discrepancy between EU regulation and the international SAE standards.

Section 5 of Annex X of EU Regulation 2018/1832 which implements the WLTP in the EU states that:

The OBFCM device shall provide for standardised and unrestricted access of the information specified in point 3, and shall conform to the standards referred to in points 6.5.3.1 (a) and 6.5.3.2 (a) of Paragraph 6.5.3. of Appendix 1 to Annex 11 to UN/ECE Regulation No 83, understood as set out in Point 2.8. of Appendix 1 to Annex XI to this Regulation.

The standards referenced above are ISO Standards 15765, 15031 and 27145. Specifically, ISO 15765 and ISO 15031 are used to define the transmission of OBD relevant information. In particular, paragraph 6.5.3.2 (a) of the WLTP regulation refers to ISO 15031-5³², which standardises the vehicle parameters that must be made available to external test equipment via the OBD port. This information is found in a digital annex to ISO 15031-5 called SAE J1979-DA. The Digital Annex was last updated in 2017 to include the OBFCM parameters listed in Annex XXII of EU Regulation 2018/1832.

The EU Regulation 2018/1832 refers to ISO 15031-5 *dated August 2015*, and this standard does not specify the version of the J1979 Digital Annex that the manufacturer is required to adhere to. However, it is considered that the Commission intends the OEMs to use SAE J1979 DA that was updated in 2017 when interpreting the amendments to Regulation 2018/1832, as the ISO 15031 equivalent regulation SAE J1979, *dated February 2017*, is also referred to.

Finally, collecting this information requires both the information to be available from the vehicle, and a scan tool able to read and download the information. There are OEM-specific OBD scan tools and

³² ISO 15031-5 “Road vehicles – communication between vehicles and external test equipment for emissions related diagnostics – Part 5: Emissions related diagnostic services” dated August 2015 or SAE J1979 dated February 2017

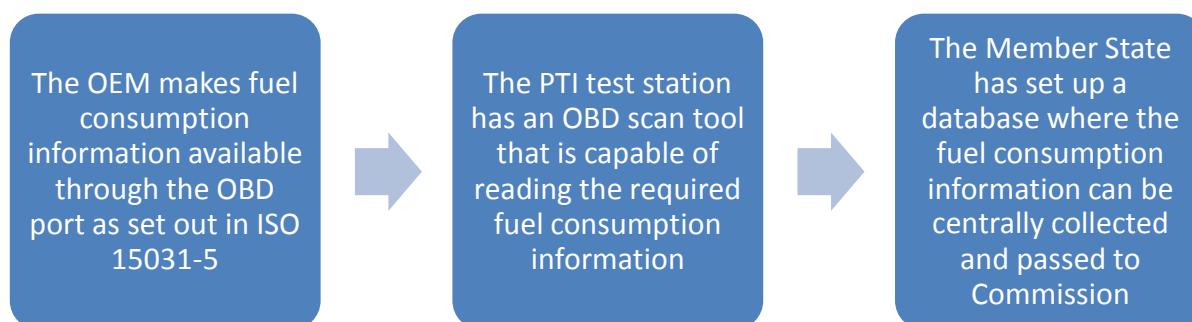
generic OBD scan tools which are standardised for use across OEMs. The generic scan tools are governed by the same OBD standards that OEMs adhere to. However, it is expected that scan tool manufacturers are '*ahead of the curve*' in updating their tools following updates to the SAE J1979 DA, in order to produce tools that the PTI stations (and other garages) are likely to need soon. While it cannot be guaranteed that all PTI garages will have the most up to date scan tools, there are scan tools on the market with the capability to download fuel consumption information if it is available from the vehicle.

7.3 Option B1: Data gathered with an EU legislative mandate

7.3.1 Introduction

The main technical considerations for the collection of data via PTIs are set out in the figure below.

Figure 7-8: Steps to allow fuel consumption information from OBFCM to be extracted from vehicles during PTIs



7.3.2 Making the information available through the OBD port

Updates to the digital annex of SAE J1979 now require all new vehicles to make fuel consumption information available to a compliant scan tool. As highlighted in 7.2.3 there is a lack of clarity around ensuring that vehicle manufacturers comply with the most recent updates to the digital annex. A legal mandate to collect this data would ensure that OEMs update their OBD's to allow for the collection of this data. Moreover, CARB highlighted that they regularly consult with vehicle manufactures when updating their SAE standard, hence there is not expected to be a significant cost to updating the vehicles with the require changes. Finally, at least one OEM reported that they do currently make lifetime fuel consumption available through the OBD port due to the requirements in the Digital Annex.

In addition to this, Verbraucherzentrale Bundesverband e.V. (VZBV), the Federation of German Consumer Organisations, highlighted that if fuel consumption data was collected during the PTI process, particularly if the data collected was included in the PTI process, then the testing and calibration of the fuel meter must also be included in the inspection process. The Federation raised the concern that the Commission has a responsibility to ensure that the data obtained is reliable (to allow for comparison with type approval emission values, one approach would be to check the calibration of the fuel meter during the PTI) While the calibration of the fuel meter is a concern for all data collection methods (as discussed in section 5.3.6, collection during the PTI process provides the opportunity to both collect, and check calibration at the same time³³.

³³ There is the potential concern that adding further steps to the PTI process would add additional time to the inspection process, this concern was not raised by the association however.

A subsequent advantage of utilising the PTI process is that it would require minimal updates for the OEMs (and scan tool manufacturers). In the US, the California Air Resource Board (CARB), which has implemented similar regulations and standards in California, works closely with the Society of Automotive Engineers (SAE) and OEMs when updating standards. New regulations are announced with adequate lead times to allow OEMs and tool suppliers to update their products before the regulation comes in to effect. This ensures that the OEMs have a detailed understanding of any changes required and can implement them in the most cost-effective way. Moreover, once a standard is updated, and once legislation mandates its use, OEMs are required to ensure their own new vehicles comply with the standard. As the SAE standards mirror the ISO standards, it is mandatory for EU vehicle manufacturers to comply with the 2017 update to the Digital Annex of SAE J1979.

7.3.3 Impacts on the PTI process

Extracting the OBFCM data would not impede or extend the PTI process. PTI scan tools work automatically once they have been plugged in. Conversations with Member States as well as *The International Motor Vehicle Inspection Committee (CITA)*, have indicated that downloading fuel consumption would not take any appreciable additional time as the amount of information is so small. Once the scan tool has been attached, the vehicle inspection can continue to conduct their tests with no impediment from the requirement to collect fuel consumption data. While this may not be considered an advantage of the PTI process, it highlights the lack of barriers or constraints to collecting the OBFCM data in the way.

7.3.4 Member State central databases

Currently, information collected during the PTI process is collected by the relevant authorities within Member States in central database(s). In order to collect and report fuel consumption, these databases would have to be updated to allow them to receive the additional information.

All four Member States consulted commented that while updates to their current central database to record the OBFCM information would be required, it was not expected to be a significant undertaking and not a significant cost.

Moreover, several parties indicated that they did not intend to create a new database to store the information but would adapt current databases used to record the current results and data from PTIs. For example, the UK reported that while the costs/challenges could not be known, it was not expected to be difficult as information was already sent from PTI stations to the central authority.

Additional costs could be faced where the relevant central authorities seek to implement an automated central reporting process (as is currently being explored in the UK). Whilst this would reduce the administrative burden in the future, there would however be additional costs associated with setting up an automated system. The UK is currently looking at implementing a system without the requirement to collect fuel consumption information, so while an automated system is relevant, it should not be considered as an additional cost that is solely related to collecting fuel consumption information.³⁴

While the costs of updating the central database are not expected to be significant according to respondents, they did comment that a lead time would be required to allow for the databases to be updated. Croatia explicitly commented that at least one year would be required to update the process.

³⁴ This section focuses on current and planned actions discussed during stakeholder consultation within the UK. While relevant, other Member States did not discuss their own plans with regard to the central PTI database and therefore it is not known whether these points are representative of other Member States.

France estimated that it would take two years to update IT systems and ensure that every PTI station had a compliant scan tool.

France further indicated that in order to begin collecting fuel consumption data they would need to liaise with a separate department responsible for CO₂ monitoring. This additional administrative step, which is unlikely to be unique to France, could increase the administrative burden on the central authority.

Finally, Member States indicated that the final step of transferring the required data to the European Commission was not expected to be a significant challenge to overcome and most expressed that “assuming the format is simple and straightforward”, transferring data to the Commission is not expected to be difficult.

Responses from the Member States about the ability to transmit information to the Commission describe the technical ability for national authorities to transmit the information. They do not touch on the potential legal limitations of passing on perceived personal information (such as VIN) to a third party.

7.3.5 A delay in accessing OBFCM data due to timing of first PTI for LDVs

On the other hand, there are limitations to utilising the PTI process to collect the required information. Primarily, as discussed previously, the gap between when the vehicle is purchased and the first inspection. The lag between vehicle purchase and data collection would significantly hinder the Commission's ability to collect comprehensive data, particularly in the very short term. Figure 7-7 showed that 5 years after the introduction of collecting the new information, less than half of the LDVs would have had their fuel consumption information downloaded.

7.3.6 Data collection independent of OEMs

The PTI process is a well-established process that has successfully been implemented at the EU level over many years. The key advantage of using the PTI process to collect fuel consumption information is that it would utilise an existing framework that is well understood. It would ensure that the process is under the control of Member States and independent of OEMs.

The requirement to collect real world fuel consumption information is born out of the gap between WLTP type approval testing and real world emissions. OEMs have a bias in wanting to avoid real world emissions to be shown to be diverging significantly from type approval emissions. Therefore, any approach that would require OEMs to collect real world fuel consumption information must consider this potential bias as a drawback. The PTI option alleviates this as OEMs are not involved in the data collection process which would increase the trust in the data collected. During the consultation in this study, inspection agencies and indeed several OEMs themselves, highlighted this benefit of the PTI option.

7.3.7 Considerations specific to Heavy Duty Vehicles

HDVs present the significant departure from the analysis of passenger vehicles due to their different PTI frequency, the weight of the vehicles (and their trailers) and its impact on fuel consumption. The following two subsections apply solely to HDVs.

7.3.7.1 The frequency and nature of the PTI

The annual PTI frequency for HDVs provides a significant advantage compared to passenger cars and LCVs where there is the (potential) four-year gap during which information cannot be collected, because the PTIs occur for HDVs annually from one year after registration.

In addition, the annual PTI inspection periods for HDVs would also ensure a consistent and comprehensive flow of OBFCM data to the Commission from all vehicles and Member States. The annual reporting will allow for a more rigorous analysis of the fuel consumption data. One of the

limitations of passenger car fuel consumption analysis is that analysis of consecutive years would not provide consistent results as the information is collected for a different set of vehicles. An annual reporting period for HDVs removes this issue as the same set of vehicles are recorded every year, allowing for a more consistent data set.

7.3.7.2 Assessing the payload of the vehicle

The other difference for collecting fuel consumption information from HDVs is the importance of the weight of the vehicle³⁵, as the rate of fuel consumption can vary significantly depending of the weight of the vehicle. Given that the payload of an HGV can vary significantly (particularly compared to a passenger car) then understanding the combined weight of the HDV is crucial to interpreting fuel consumption, especially when comparing to the official type approval values.

Moreover, as the HGV is loaded and unloaded throughout its operation, understanding the role that weight plays on a vehicle's fuel consumption is more complex than simply weighing the vehicle during the PTI. However, one of the key challenges of calculating payload – knowing the kerb weight – could be addressed if kerb weight information is collected during PTIs from direct measurements or the driver. Section 6.3.2.4 discussed in more detail the challenges of calculating payload, and the possible solutions.

At least one HGV OEM does currently record the GTW of the vehicle over time which could be combined with fuel consumption information. The need and ability to incorporate GTW in to fuel consumption information requires further analysis to determine feasibility. It is worth noting however that this limitation applies to all the options discussed in this report.

7.3.8 The need to have OBD scan tools able to access the OBFCM data

As discussed previously, the manufacturers of OBD scan tools are often ahead of the curve (compared to OEMs) when implementing new requirements, to avoid tools becoming redundant, therefore it is likely that many PTI stations with new scan tools will already have the required equipment to collect the necessary information.

New OBD scan tools are expected to be compliant with the 2017 update of the SAE J1979 Digital Annex, as changes to new tools are often decided while the revision of applicable standards are taking place to ensure compliance. Moreover, representatives of tool developers often support the standards authority (either the ISO or SAE) when updating standards that impact the tools to understand the changes and support implementation.

During the stakeholder consultation Member State authorities and PTI organisations were asked to estimate the costs of implementing the updated requirements included with the 2017 SAE J1979 Digital Annex. While no respondent could provide an estimate of the costs associated, qualitative responses shows the variations in the updates and potential associated costs across the EU. For example, the *Asociacion Espanola de Entidades Colaboradoras de la Inspeccion Tecnica de Vehiculos*³⁶ reported that “the additional cost would come from software updates and the management of the study for those involved and some little training for the inspectors”.

All new OBD scan tools will have been updated to include the requirements set out in the Digital Annex. The outstanding question therefore remains if the existing OBD tools can be updated or if new tools need to be purchased.

Concern was raised about PTI garages who may have recently purchased new OBD scan tools in order to be compliant with the 2023 roadworthiness directive deadline. There was concern that if OFBCM

³⁵ This primarily refers to HGVs that are used to transport goods, there are HGVs with other purposes that would not face this same difficulty.

³⁶ Spanish Association of Collaborating Entities with the Administration in the Technical Inspection of Vehicles (iTV)

data was made compulsory then these new tools could become redundant. However, while some stations with older scanning tools may have to purchase a new tool, consensus suggests that the newer scan tools have the option to be updated remotely. Therefore, garages that have recently purchased a new OBD scan tool will not have to purchase a new tool in order to comply with the legal mandate.

The concern here is twofold, firstly, a large number of PTI stations would be required to purchase a new tool. Conversations with Member State authorities have indicated that in many cases, the companies that carry out these checks are small independent garages or self-employed people.

The need to purchase a new OBD scan tool would place an additional requirement on them which would not exist if not for the requirement to collect this information, assuming they do not already have a scan tool or if the tool they already use is old and does not allow for software updates to be installed. However, while this would be an additional requirement on the PTI garages, newer scan tools that collect OBFCM information are not considered expensive and therefore there would not be a significant financial burden placed on PTI stations. Unfortunately, the stakeholder consultation conducted did not provide any insight on the cost associated with updating scan tools within a country. However online research suggests that they are inexpensive and should not be a financial burden to the PTI garage.

Secondly, while the newest scan tools can download fuel consumption information, requiring a significant number of PTI stations to purchase a tool in a relatively short time could potentially be difficult for manufacturers. Representatives from the French authorities³⁷ indicated that they believed that new scan tools would be required.

Overall, there were conflicting opinions among the consulted Member States and other authorities associated with the PTI process on whether scan tools would need to be repurchased or updated. Recently purchased, and more technically sophisticated scan tools can be upgraded to collect the additional information, however older tools will likely need to be replaced. No stakeholder contacted was able to give an estimate on the number of tools that would need to be repurchased as opposed to upgraded. Therefore, this report does not fully assess the cost associated with requiring the collection of OBFCM data through the PTI.

7.3.9 Costs

As discussed above there are conflicting views on the requirement to purchase new OBD scan tools. This is one of the key limitations hindering a comprehensive analysis of using the PTI process to collection fuel consumption information. All four Member States consulted reported that they could not provide accurate cost information associated with upgrading OBD scan tools as they did not know how many scan tools would need to be purchased (as opposed to upgraded).

While this is a significant gap in the analysis, the cost of a compliant scan tool is not expected to be significant. Hence while the aggregate cost of purchasing new scan tools across a state or region may be large, the cost to an individual PTI station or mechanic is not expected to be.

The other expected cost is the update required to Member State databases required to collect the addition OBFCM information. The Member States consulted reported that they did not expect the upgrades required to central databases to be a significant cost and that the additional information could be collected relatively easily.

³⁷ Ministry for an Ecological and Just Transition (General Directorate for Energy and Climate Change), and the Union Technique de l'Automobile, du Motocycle et du Cycle Union de Syndicats (UTAC CERAM), the dedicated central technical body for PTIs in France

7.3.10 Summary of strengths and weaknesses of option B1

- + Data collection would be independent of OEMs and couldn't be considered open for bias
- + High data collection coverage – every vehicle that attends a PTI would be covered
- + Data on real world fuel consumption of HDVs could be obtained annually
- + Extracting the OBFCM data would not unduly impede or extend the PTI process
- +/- unknown costs impacts of new OBD scan tools, but likely to be small
- + Low cost burden expected for Member States to extend existing databases
- A delay in accessing OBFCM data due to timing of first PTI for LDVs
- Requiring a significant number of PTI stations to purchase a tool in a relatively short time could potentially be difficult for tool manufacturers
- Member States would report information at different frequencies, making it difficult to conduct analysis between different countries of the latest 12 month period.

The key advantage of making the collection of fuel consumption data during the PTI process a legal requirement is that it should result in data being collected from every vehicle. Currently all LDVs are required to undergo a technical inspection at least every two years. Therefore, the Commission would receive the fuel consumption information for all LDVs based on data collected in the last two years following the first PTI.

While the heterogeneous collection process that occurs in Europe would mean that countries would be reporting at a different frequency, this methodology would ensure that, four years after the registration of a vehicle, accurate fuel consumption data would be available on all vehicles from that year. Moreover, given the nature of PTIs in Europe, ensuring that VIN is collected alongside OBFCM data for all vehicles, would allow for a considerably more accurate assessment of how fuel consumption, and emissions change across time, minimising the impact of the inconsistent reporting period between Member States.

While requiring PTI stations to collect fuel consumption information via EU legislation would ensure that the Commission received comprehensive information on the fuel consumption of vehicles, the need to implement a new piece (or amendment) of legislation may be a barrier.

Introducing a legal requirement to collect fuel consumption data during PTI will require careful consideration of the legal framework. In particular, it could be argued that information on fuel consumption is not directly related to roadworthiness, so it needs to be seen how such requirement would fit in. Furthermore, consideration needs to be given to the time needed for amending, agreeing and implementing new legal requirements in view of the time frame foreseen for the start of the data collection.

7.4 Option B2: Data gathered without a legislative requirement at EU level

Option B2 assumes that there is no legislative requirement at the EU level and requests Member States to institute a legal basis for collecting the OBFCM information, either via owner consent or a national legal requirement for collect the information during a PTI. Any data collected by Member States should be provided to the European Commission, but without a legal mandate this may not be possible to require.

The section looks at the specifics associated with collecting fuel consumption information by way of a consent, including discussion technical considerations associated with the option, and potential strengths and weaknesses. Many of the considerations associated with a Member State legislative mandate are the same as those discussed in B1.

As highlighted above, the process of allowing additional information consumption via consent is not permitted in some Member States. In Spain, only data that is legally required is allowed to be collected during the PTI process, even if consent was granted for additional information collection, it would not be legally permitted, hence a Member State legislative requirement would be necessary.

Even when consent can legally be collected within a Member State, it would not be possible to achieve the level of coverage (number of vehicles) received by a legislative mandate for collection, as a proportion of the population will likely refuse to give consent. Moreover, unless PTI inspectors are required to explicitly ask if they would like this additional information to be collected then consent may not even be required. Anecdotal evidence suggests that conducting a PTI involves little to no paperwork. Therefore, if inspectors are asked to seek consent for the data collection that considerably impedes the way they work or adds a significant time delay to their work then they are unlikely to actively request the additional data.

Even when vehicle inspectors do request the collection of VIN and OBFCM data, it is likely that only a small proportion of the population would willingly hand over personal information, (particularly in states where VIN is considered highly personal).

7.4.1 Technical considerations

The same technical considerations discussed in Figure 7-8 also apply in option B2, in other words, in order for fuel consumption information to be collected, the following need to occur:

- The OEM needs to make the fuel consumption information available through the OBD port.
- The PTI station needs an OBD scan tool that is capable of reading the new fuel consumption information provided by the on-board device.
- The Member State central authority needs a database that is capable of storing the new information and making it available to the European Commission when required.

These technical considerations are discussed in the following sections. While there is no legal mandate requiring the above to happen, there are several ISO and SAE standards in place that require OEMs to record the required OBFCM data and make it available via the OBD port. While this is not yet ubiquitous, new models of vehicles are beginning to incorporate the required information in to the on-board device as OEMs begin to catch up to the recent changes in the SAE digital annex. We can therefore reasonably expect that within a short period of time all new OEMs have made the required information available within their vehicle.

Like the new vehicles, new OBD scan tools are also being updated to reflect the changes to the SAE digital annex. Stakeholder discussions suggested that all new OBD scan tools will likely already be able to collect the information from the on-board device. The potential issue is that without a legal authority to collect the information, PTI garages have no requirement to purchase a new tool or update their tool to include the required information. Without these steps, collecting consent from customers will be irrelevant without method of collecting/reading the required information. Furthermore, even if garages do update their tools and purchase new scan tools, unless the Member State competent authority provides a mechanism for the collection, centralisation and transmission of the information to the commission, then there is no point collecting the information in the first place.

7.4.2 Member State legislation

As discussed, one of the key drawbacks of this option is that some Member States do not permit the collection of any information during the PTI process that is not required by law (such as in Spain and The Netherlands). The lack of European level legislation requiring the collection of fuel consumption information would not preclude Member State level legislation from being updated or implemented to either allow for the collection of the required information or to ensure comprehensive coverage within a country.

Under option B2, Member State legislation would be essential (in some countries) in order to collect a significant level of fuel consumption information that spanned all Member States. Implementing Member State level legislation would also have similar disadvantages to those discussed in B1, specifically the time in implementing new legislation, moreover, a devolved legislative approach would run the risk that information collected would not be harmonious across different regions, making it more difficult to collect and analyse at the EU level.

7.4.3 Considerations specific to HDVs

There are no specific changes to HDVs associated with not utilising a legal mandate. However, as highlighted previously some Member States employ a more centralised approach to conducting PTIs on HDVs, as reported by the UK. If the PTI process is carried out by a government body then there may be less barriers to collecting fuel consumption information without a legislative mandate. Specifically, if centrally run, measures could be put in place to ensure that all garages are equipped to collect the information (at the very least) rather than having to rely on every privately owned garage choosing to update.

7.4.4 Summary of strengths and weaknesses of option B2

- + No additional legislative requirement at the European Level
- + Member States can choose to collect information in the best way for them.
- In some countries, OBFCM data cannot be collected without a legislative requirement to do so.
- Much less information collected as people would not wish to relinquish their personal data.
- Where required, consent would be collected at every PTI, adding time to the streamlined process.
- Fewer PTI garages would have updated scan tools than under Option B1

The main advantage of option B2 is that it required no additional legislative action to collect the desired information. As highlighted in option B1, there is the potential for several barriers to passing legislation, at the EU level that would require the collection of the information. Pursuing a voluntary approach could mitigate the requirement.

Moreover, several of the steps required to collect the necessary information are already occurring without a legal requirement. By 2021, all vehicles will be required to make fuel consumption information available, new scan tools already allow for the information of OBFCM data and by 2023, all PTI stations will be required to have a scan tool.

While Member States are not required to update their central data bases, many we spoke to are currently doing so anyway. The Commission could incentivise other Member State to update their systems by highlighting the advantages to them too, for example knowing fuel consumption would allow countries to more accurately report their fuel consumption emissions and develop further climate/transport policies.

However, despite this, there are key limitations that would restrict the collection of fuel consumption information. As mentioned, in Spain, and also in the Netherlands, only data that is legally required can be collected during a PTI, therefore unless these government mandates the collection of OBFCM information it cannot be collected. In another situation, Croatia reported that the OBD scan tool used in PTIs is centrally mandated by the government. Therefore, without a requirement from the EU, it may be that Member States choose a scan tool that does not have the functionality to collect fuel consumption data. In this situation, PTI stations could not report the information even if they wanted to.

The key limitation remains the requirement to collect consent from each vehicle owner, given that owners do not personally benefit from the collection of the information and the perception that this information (particularly VIN) is personal information, it is likely that many will not consent to provide the information.

In short, the option for people to not provide consent, for PTI stations not to upgrade or purchase a scan tool that can collect the information, and for some Member States to not permit the collection of the data that is not legally required would result in a significant section of EU vehicle fleet for which data will not be collected (assuming they chose not to legally require it). This highlights the severe limitation of attempting to collect fuel consumption information without a legal mandate, there are too many groups for which information is not collected and therefore a complete and representative sample would not be collected.

7.5 Conclusions on Option B

The viability and success of collecting fuel consumption information during the PTI process depends on the sub-option considered. Option B1: ensuring data collection occurs through a legislative mandate would allow for the near universal collection of fuel consumption information and provide 'legal obligation' for the relevant information to be collected. Option B2 seeks to collect fuel consumption without a legislative mandate and would require owner consent in order to access the OBFCM information every time someone brings a vehicle in for a PTI.

Analysis of both sub-options has shown that option B1 has significant advantages over B2, given that it would result in almost universal coverage which B2 suffers both from the possibility that some users may not provide consent and that in some Member States, information cannot be collected during PTI process without a legal requirement to do so.

An advantage that applies to both options is that it is expected to be relatively inexpensive. The stakeholder consultation did not allow for an analysis of the cost involved however Member States did comment that they did not expect the requirement to update their databases to be a large expense. Moreover, while some PTI stations will incur an expense if required to purchase a new scan tool it is not expected to be large. In addition, the requirement for all PTI stations to have scan tools by 2023 and that current or recently purchased scan tools can read fuel consumption information (or have software updated to allow it) suggests that a large proportion of stations will have compliant scan tools.

A further advantage is that the process is independent of OEMs, given the vested interest of car manufacturers to have real-world fuel consumption match with type approval values, ensuring that fuel consumption information is collected independently removes any potential bias³⁸.

The biggest weakness of this option (applying to both sub-options) is the significant time gap before the first PTI for passenger cars and LCVs. The time gap is a significant weakness for two reasons: firstly, newer vehicles are typically used more and driven further than older vehicles (see Figure 7-3). Therefore, newer vehicles will emit more CO₂ over a period where they cannot be monitored, and their

³⁸ These advantages apply to HDVs as well as passenger cars and LCVs.

emissions are not known. Secondly, the Commissions intention to analyse real world fuel consumption of new vehicles between 2021 and 2026 and analyse these findings in 2027 presents a small window in which data can be collected. If fuel consumption information cannot be collected for the first 3 or 4 years of this period, then it further restricts the number of vehicles which can be analysed. Moreover, there will only be one year, vehicles registered in 2021, where the entire fleet for that year will have received more than one PTI allowing for limited analysis across time.

While this is a significant limitation for passenger cars and LCVs, HDVs do not face the same challenge. The Roadworthiness Directive requires HDVs to undergo an inspection annually, this will allow for much greater insight on how fuel consumption changes across time and also remove the issues from a heterogeneous inspection timeframe faced by passenger cars and LCVs (discussed below).

On a related note, the inconsistent PTI periods across Member States would mean that the Commission would receive information on vehicles of the same age at different points in time, depending of country in which a vehicle is registered in, potentially resulting in further time lag before pan-European datasets can be compared for a particular vehicle model.

It could potentially be difficult to compare results across Member States. In the UK, the PTI test frequency is 3-1-1 (i.e. first PTI occurs after three years, followed by testing in each and every subsequent year), whereas in France the test frequency is 4-2-2 (i.e. first test after four years and then subsequent tests every two years). While the assessment of fuel consumption is a ratio of fuel consumption/distance driven and therefore the two are comparable, the two are not contemporaneous and therefore subject to variations in external factors. Nevertheless, while noteworthy, given the number of other external factors that will impact fuel consumption, it is not expected to be a significant factor.

To conclude, both sub-options B1 and B2 are inexpensive and independent ways of collecting OBFCM information, however the near universal coverage that would be provided by a legislative mandate (as set out in B1) makes it the preferred option, particularly given that there are several countries that would not be able to collect the information without it. Both options present a serious limitation, given the 3 or 4 year lag before information can be collected (excluding HDVs), however this could potentially be dealt with by pairing the approach with one of the ad-hoc sampling methods to bridge this gap.

8 Option C: Ad-hoc Sampling

8.1 Overview of Option C and sub-options assessed

This option is concerned with the ad-hoc sampling of vehicles. This option includes four sub-options, some of which can be considered complementary to Option B (Periodic Technical Inspection, see Section 7), whereas the others should be considered as standalone/alternative options. The reader should refer to previous sections for detailed discussion where indicated. The four sub-options for ad hoc sampling are as follows:

- C1: Ad hoc sampling during vehicle servicing by OEMs (complementary);
- C2: Ad hoc sampling via other vehicle emission verification activities (complementary);
- C3: Ad hoc sampling of selected fleets (information provided by fleet managers); and
- C4: Ad hoc sampling of EU vehicles using OTA /PTI – a voluntary measure.

8.2 Background: the need for complementary options

The lack of fuel consumption information available to the Commission before the first PTI is carried out is a considerable limitation for Option B. At the very least, the first full data set for one registration year would not be available until 2025, assuming implementation of a PTI-based data collection process from 2021.

For the PTI option (Option B), it was identified that the first PTI of new passenger cars must occur, at the latest, four years after the vehicle was first registered (the specific time period varies by Member State). This is a considerable limitation of this approach – the first full dataset from vehicles registered in 2021 would not be available until 2025 (assuming a 2021 rollout). This results in a delay in access to data for the first few years of after vehicle registration, whereby the data is not accessible to the Commission until 2024 or 2025. Furthermore, due to the typically higher distances driven in the first years of a vehicle's life, the gap is disproportionately larger for this period. The Roadworthiness Directive requires that HGVs are to be presented for inspection annually, so the same data gap does not exist for HGVs.

There may also be gaps in the data collected OTA (Option A) depending on the OTA connectivity used, and the potential length of time for OEMs to implement this within vehicles.

Options C1 to C4 could potentially address these data gaps.

8.3 C1: Ad hoc sampling via OEM vehicle servicing

8.3.1 Overview

This option proposes that information could be downloaded from a vehicle's OBFCM via an OBD tool that records fuel consumption data when vehicles are presented for servicing, by either OEMs or independent garages performing the services. This would be a way to record the data for some vehicles prior to their first PTI. OEMs and independent garages would be required to submit data to a central Member State database, for subsequent submission to the Commission. It is likely that this would be voluntary data collection (although legislating the requirement to collect and submit data during vehicle servicing could be considered), and would therefore not cover the entire vehicle fleet, but capture some of the data missing vis Options A or B. It is not intended to be a standalone option, but to complement Options A or B in order to increase the coverage of data collected during the first few years of data collection.

EU legislation³⁹ requires that all manufacturers offer a minimum two-year and unlimited mileage car warranty on all new cars (regardless of change of ownership). Vehicle manufacturers set a recommended servicing schedule, with the first service typically occurring between 1 and 2 years or up to a specific distance (usually between 15,000 and 30,000km)⁴⁰. All the OEMs interviewed for this report indicated that new vehicles are issued with a warranty that is conditional⁴¹ on the vehicle being regularly serviced. During these services, a variety of checks are carried out, and at some garages, an OBD scan tool is used to collect diagnostic information. Table 8-1 shows the frequency of when services (either fixed or flexible), included in the warranty, are carried out in new vehicles.

Table 8-1: Services included in the warranty of new vehicles

Manufacturer	Fixed Service Check	Flexible Service Check
Audi	After 15,000 km or 1 year	Between 15,000 – 30,000km and 1-2 years
BMW/Mini		After 30,000 km or 2 years
Ford	After 20,000 km or 1 year	
Honda	After 20,000 km or 1 year	After 20,000 km or 1 year
Hyundai/Kia	After 30,000 km or 2 years	
Mercedes	After 25,000 km or 1 year	
Nissan	Diesel: after 30,000 km or 1 year Petrol: after 20,000 km or 1 year	
Opel	After 30,000 km or 1 years	
PSA	15,000-30,000km or 1 year	15,000-30,000km or 1 year
RSA	After 30,000 km or 1 year	
Skoda	After 15,000 km or 1 year	Approximately after 1 year
Toyota	Petrol: 15,000 km or 1 year	Diesel: 15,000-20,000km or 1-2 years
Volvo	After 30,000 km or 1 year	
Volkswagen	After 15,000 km or 1 year	Between 15,000 – 30,000km and 1-2 years

It could be possible to collect fuel consumption data during these vehicle services during the warranty period up until the vehicles receive their first PTI. Importantly, this would provide an opportunity for information to be collected prior to the first PTI test.

While there is no legal requirement for vehicle owners to present their vehicle for servicing, adhering to the OEM schedule for servicing is recommended in order to ensure warranties remain valid. Without regular servicing undertaken according to the vehicle's manufacturing service manual and the use of parts of the same quality as the original equipment fitted in the vehicle (if undertaken at an independent garage rather than by the OEM), the OEM warranty becomes invalid. Regular servicing also maintains vehicle safety and maximise the vehicle's lifespan, to enable the potential for vehicle owners to save money (through early fault diagnosis) and to maximise resale value. Therefore, there is an incentive for vehicle owners to present their vehicle for servicing during (at least) the first two years following vehicle

³⁹ Directive 1999/44/EC on certain aspects on the sale of consumer goods and associated guarantees – consumer legislation

⁴⁰ Recommended servicing schedules vary between OEM, and within OEMs depending on the Member State.

⁴¹ The exact conditions vary by Member State and vehicle manufacturer

first registration. In some cases, OEMs offer longer vehicle warranties, although these are often limited by mileage.

8.3.2 Advantages

The main advantage of this sub-option is the potential for addressing the data gaps identified for Option B for the first four years after registration of new passenger cars, thus it could complement fuel consumption data collection through the regular PTI. To some extent, this option could also complement data collection for Option A where there is limited OTA capability for some vehicles.

In terms of coverage and potential fleet sample size, the proportion of vehicle owners returning to the OEM/franchised dealership to have their vehicle serviced during this period is unknown (owners are entitled to take their vehicles to independent garages for regular servicing). Discussions with OEMs indicated that the proportion of new vehicles that are presented to OEMs/franchised dealerships for vehicle servicing prior to the first PTI is likely to be high, due to the requirements of the obligatory free two-year unlimited mileage warranty (which will often only remain valid if parts used are approved by the manufacturer and the service occurs according to the manufacturer's recommended schedule).

8.3.3 Weaknesses

To some extent, the same issues arise as for the PTI option. Those performing the servicing of vehicles will face similar issues regarding the potential need to upgrade their scan tools (see also Section 8.3.4 Technical Considerations). Several Member States discussed the need for a significant lead time (2-3 years), due to the substantial undertaking required for new scanning tools to be designed, manufactured and sold to garages/manufacturers undertaking servicing in Europe.

Whilst in some Member States the PTI and vehicle servicing is undertaken by the same entity, this is not always the case. The UK reported that approximately 75% of franchised dealers are also registered PTI centres (estimated by DVSA) – therefore, it may be easier to integrate the collection process during servicing at these sites. However, this is not the case for all Member States. For example, it was reported that PTI test centres are typically separate entities to franchised dealerships undertaking servicing in France, due to the perceived conflict of interest (performance of PTI test and subsequent repairs). It is also understood that not all vehicles that are presented for servicing will necessarily visit a read-out point (where OBD tools are used), so an additional step may be required when obtaining fuel consumption data, which would be voluntary. Where the servicing of new vehicles is performed by a different entity to those performing PTIs, there will be a period of (up to) four years where they are expected to collect fuel consumption data from vehicles and subsequently collate and transmit to the Member State. An additional reporting mechanism will need to be in place before the responsibility is transferred to the PTI stations whereby fuel consumption data can be collected and stored during vehicle servicing, including the ability to integrate it into the Member State's PTI reporting system.

As mentioned earlier, there is no legal requirement for vehicle owners to present their vehicles for servicing with OEMs (or independent garages). Therefore, there is a risk that vehicles will not be presented for service during the period of first registration and first PTI, although it is considered that this risk is very small (based on requirement to fulfil servicing schedule in order to validate OEM warranty during first two years since first registration). Option B outlined the advantage of legislating the collection of fuel consumption data during PTIs to ensure that data could be collected from every vehicle (see Section 7.3). Similarly, legislating the requirement to collect fuel consumption data each time a vehicle was presented for servicing would also be desirable to ensure data covering the majority of the vehicle fleet. However, it is unlikely that this could be legislated due to the fact that there is no legal requirement for vehicles to be serviced – the process would therefore be voluntary. Finally, there remains a limitation with this approach as the recommended servicing frequency (as outlined in Table 8-1) varies between OEM. Therefore, a consistent dataset still could not be collected as four OEMs only recommend service checks two years after vehicle registration.

8.3.4 Technical considerations and costs

The main technical considerations and costs associated with this sub-option are similar to those outlined for Option B, considering both with and without a legal mandate to collect the data.

They include the following:

- In-vehicle (see section 7.3.1 and 7.4.1);
- The OBD scan tool (see section 7.3.2 and 7.3.8);
 - Scan tools capable of retrieving fuel consumption data will also need to be available to those performing servicing of new vehicles (if not the same entity undertaking PTI).
- Member State central databases (see section 7.3.4).
 - Data will be collected by OEMs or independent garages responsible for undertaking the vehicle servicing within each Member State. There will need to be an ability to collate and integrate fuel consumption data into Member State central database (that will have to have been developed for either Option A or B), and data will subsequently be submitted to the Commission.

The requirement to collect and make available data of fuel consumption from new vehicles from 2021 is discussed in more detail in Section 7.2.3.

8.4 C2: Ad hoc sampling via other vehicle emission verification activities

Option C2 is concerned with the **ad-hoc sampling of vehicles to obtain fuel consumption data during existing vehicle emission verification activities** such as the In-Service Conformity (ISC) tests.

Vehicle manufacturers are required (under Regulation 2018/1832) to undertake ISC tests on a sample of vehicles in relation to a vehicle's emissions. In theory, the ISC test could provide an opportunity for additional fuel consumption data to be collected and potentially address the data gap identified for Options A and B. However, the required sample size for ISC tests as set out in the Regulation (see Table 8-2) represent a very small proportion of the vehicle fleet, thus making Option C2 unfit for purpose.

Table 8-2: ISC sampling requirements

EU Registrations (for each family)	
• Per calendar year (for tailpipe emission tests)	Number of sample lots*
• Of vehicles of an OBD family with IUPR in the sampling period	
Up to 100,000	1
100,001 to 200,000	2
Above 200,000	3

**Each sample lot is minimum 3 vehicles, maximum 20 vehicles.*

For each family, the number of sample lots is based on sales volumes. Therefore, a family with over 200,000 EU registrations would be required to undertake 3 sample lots (varying between 3 and 60 vehicles).

8.5 C3: Ad hoc sampling of selected fleets (information provided by fleet managers)

Option C3 is concerned with the **ad hoc sampling of selected fleets**. This option could be applicable to fleets of LDVs (e.g. taxis, rental and lease companies, company cars etc.) and/or HDVs (e.g. logistics companies).

Fleet managers regularly collect a range of data on their fleets, including total distance travelled and average fuel efficiency (litres/km). Data are often collected via OTA equipment which is already installed in the vehicles (typical for HDVs, possible for LDVs). Devices are available that can be installed in vehicles to record fuel consumption data with a high degree of accuracy. The fuel consumption data can be stored in the vehicle and transmitted automatically (at a high interval frequency, e.g. every 90 seconds). Distance travelled data could be obtained if the device is connected to the tachograph (for HDVs), or obtained via GPS.

The European Commission would be responsible for determining the sampling frequency, sample size, segmentations and geographic location etc. However, they may consider using existing vehicle fleets. A direct request to fleet managers would be required in order to request the data. Data collection would need to be standardised across fleets/manufacturers to ensure appropriate calculation of fuel consumption and levels of accuracy. Feedback from one fleet manager suggested that they would be willing to provide annual aggregated (for a group of vehicles) fleet data to the European Commission, including VIN, real-world fuel consumption data and distance travelled. However, in order for this approach to be considered a success, it needs to be as easy as possible for fleet managers to supply the required data.

Data collection would be voluntary, with a request being made to fleet managers to collate the required data from their fleet. Data would be subsequently submitted to the Commission.

8.5.1 Advantages

The main advantage of ad hoc sampling of fleets is the potential for the collection of data in the absence of widespread data collection via OTA or PTI. The capability to collect this data is available, so it is just the mechanism for collating and submitting data to the Commission that is outstanding.

The samples that could be achieved via ad hoc sampling of fleets are potentially much larger than for Option C2. There is also much less dependence on OEMs to collate and supply the data.

8.5.2 Weaknesses

Regarding the use of selected fleets for the purpose of collecting fuel consumption data, concerns have been raised by OEMs regarding its usefulness, representativeness of the selected vehicles (of the EU vehicle fleet) and how they have been used.

It was suggested by one stakeholder that this approach to monitoring real world fuel consumption data would lose the originally intended purpose – to collect a comprehensive view of real-world fuel consumption of the EU vehicle fleet (usage and geographically).

For HDVs, and the use of logistics companies in ad hoc sampling of fleets, usage considerations are not necessarily an issue – they are likely to be most representative of HDV use. However, the use of LDV fleets for sampling to collect data may present concerns relating to ‘typical’ use. For example, there are differences between commercial and private drivers of LDVs – fuel costs to the user are likely to differ, potentially impacting on how the vehicle is driven, and corresponding fuel use. Fleets of taxis, rental vehicles, company cars cannot be considered representative of the usage of the private LDV fleet. See also Section 5 on data analysis considerations and the factors that can influence fuel

consumption and representativeness of samples. Therefore, the process of selecting fleets could lead to issues relating to representativeness of the vehicle fleet and its use.

Very few fleet managers responded during the consultation for this study, so limited feedback on the feasibility of the option was gained. The motivation or incentive for fleet managers to provide the data is potentially lacking, although feedback from one fleet manager was that they would be willing to provide data annually.

8.5.3 Technical considerations and costs

Costs and administrative burden will largely be on the fleet managers providing the data. Although data is already regularly collected, it will be required to be stored and reported in a specified format.

Member States will also be required to develop a central database to store, aggregate and transmit data to the Commission (as required for Options A and B), unless fleets are approached on an EU basis (rather than Member State level). There are no data available on potential costs.

8.6 C4: Ad hoc sampling of EU vehicles using OTA / PTI.

This sub-option is concerned with developing a sampling regime for the EU vehicle fleet, collecting data using either OTA or PTI methodologies as an alternative to Options A and B, which aim to cover as much of the EU vehicle fleet as possible. The difference between Option C4 and Options A and B is that there would be no legal mandate, and not all vehicles would be targeted for data collection.

The European Commission would be responsible for determining the sampling frequency, sample size, segmentations and geographic location etc. OEMs (OTA) or PTI authorities (PTI) would be approached in order to request that they collect the required data. Data would be subsequently submitted to the Commission.

The sample could be voluntary: for example, if an incentive is provided for the provision of data.

8.6.1 Strengths

Using a sampling approach would potentially reduce the financial and administrative burden of fuel consumption data collection from the EU vehicle fleet. Rather than widespread collection of data OTA or via PTI, targeted sampling using the same techniques could be undertaken.

The widespread need to purchase/update scan tools would be significantly reduced.

8.6.2 Weaknesses

As previously noted, stakeholders have raised concerns regarding the representativeness of any sampling activities undertaken, including vehicle type and number of vehicles. This would also be a voluntary action on the part of OEMs (OTA) and PTI authorities (PTI). A sample that is based on a voluntary approach with an incentive for the public to provide data would also lead to concerns over the bias in the sample. The concerns regarding representativeness would relate to whether each vehicle segment across the different manufacturers is sufficiently represented. Concerns regarding bias may relate to a self-selecting sample not having a real world fuel consumption performance differing from the WLTP in the way that the total population of vehicles fuel consumption differs from the WLTP.

Applus +, a testing, inspection and vehicle certification organisation in Spain, reported that it is forbidden for companies that carry out PTIs to read or save any information other than those required by law. This would suggest that at least in Spain, a voluntary sample-based collection approach (not mandated by EU or Spanish law) would not be possible.

8.6.3 Technical considerations and costs

Technical and cost considerations relating to the collection, storage and transmission of fuel consumption data via OTA and PTI methodologies are discussed in more detail in Section 6.3.3.3, Section 7.3 and Section 7.4 (PTI) respectively.

As stratified sampling of the EU vehicle fleet would be undertaken for this sub-option, the costs and administrative burden incurred is likely to be on a smaller scale.

8.7 Conclusions of Option C

Four sub-options have been considered:

- C1: Ad hoc sampling during vehicle servicing by OEMs (complementary);
- C2: Ad hoc sampling via other vehicle emission verification activities (complementary);
- C3: Ad hoc sampling of selected fleets (information provided by fleet managers); and
- C4: Ad hoc sampling of EU vehicles using OTA /PTI.

One of the key challenges for the PTI option (Option B) was the significant gap in data collection prior to first PTI, meaning the Commission would not be able to assess the accuracy of new passenger cars and how they compare to official type approval values until around 2025. **Option C1**, ad hoc sampling via OEM vehicle servicing, presents an opportunity to address this gap. Although servicing of vehicles is not a legal requirement, it is understood to be undertaken regularly during the first few years following first registration, particularly to ensure that the OEM minimum two-year warranty (legal requirement) remains valid. Whilst a legal requirement could not be introduced to mandate the collection of data during servicing, any data collected via OEMs during servicing will contribute towards bridging the data gap for Option B.

In contrast, whilst the collection of fuel consumption data from passenger cars via other vehicle emission verification activities such as via the ISC is feasible (**Option C2**), the small sample sizes required per manufacturer means that this is not a viable option for bridging the data gap due to the lack of representativeness of the EU new passenger car fleet.

Option C3, the ad hoc sampling of selected vehicle fleets, could be considered as an alternative to Options A (OTA) and B (PTI). As data is regularly collated by fleet managers, feasibility of data collection is high. However, issues relating to representativeness of the selected sample and the potential differences in the use of fleet vehicles compared to the EU vehicle fleet as a whole raise concerns regarding its suitability.

Option C4 takes a voluntarily elected sampling approach to collecting fuel consumption data either via OTA or when presented for PTI. Strengths include reduced costs and requirements for scan tools. However, it would take a voluntary approach to gathering and submitting the data to the Commission. There are also concerns regarding the representativeness of the samples achieved (EU vehicle fleet, geographical spread, usage) and bias.

9 Conclusions

Data protection considerations common to all options

- Across all the available options, possible restrictions regarding the collection of personal data need to be considered. The data to be collected – **Vehicle Identification Number (VIN) together with distance travelled and fuel and/or energy consumed – could be considered as personal data under the General Data Protection Regulation (GDPR), if the owner of the vehicle is identifiable from the information.** Where the data is considered personal data under the GDPR, a lawful basis would be needed for processing of the data
- **For data sought through a non-mandatory request, the prevailing lawful basis through GDPR is the consent of vehicle owners** to provide the requested data. **For data collected under a mandatory requirement** – whether the means is over-the-air, or through periodic technical inspections, or another route – **the lawful basis under GDPR moves from consent to ‘legal obligation’ or ‘public task’.**
- For processing of personal data, also the basic principles for processing outlined in Article 5 of the GDPR need to be complied with. For example, **the purpose of the data collection needs to be clearly defined, and no more data should be collected as necessary to fulfil the purpose.** To this end, section 5 describes the types of analyses that could be conducted depending on the data collected.

Data analysis considerations

- Several factors influence the real-world fuel consumption of vehicles and there can be considerable variation between vehicles, manufacturer fleet averages and Member State averages, as well as over time. Averaging vehicle data across vehicles and over time (one year or longer) will significantly reduce this variability.
- While aggregating the data may help to normalise some of the influencing factors, this should not remove the ability to analyse the data in detail in order to achieve a meaningful comparison with type approval data (WLTP data for LDV and VECTO data for HDV). Furthermore, aggregation should be consistent over consecutive years to ensure that averages can be compared and trends monitored.
- Average speed is an additional parameter that we recommend should be collected in order to enhance the data analysis.
- The collection and analysis of the OBFCM data should be approached as an iterative process. The conclusions that can be drawn from the data analysis depend on the quality and quantity of data collected. As trends start to appear over consecutive years of data collection, adjustments may need to be made to the way that the data is processed to ensure that meaningful conclusions can be drawn from the data in 2027.
- In order to compare annual trends, identify corresponding TA values and track the data collected, the VIN should be retained, at least in a truncated form (VIN characters 1-11). While annual trends can be compared at the aggregate level, and corresponding TA values can use the interpolation family from a truncated VIN (Characters 1-11), the full VIN would be needed to be able to identify duplicate records. However, this check may only need to be carried by the EC/EEA out if the data is reported direct to the Commission. In other reporting options, the OEM or MS could carry out this check.

Summary of the options

The following tables summarise the positives (✓), negatives (✗) and points for information (❗) that are neither for each option.

Options relating to the collection of OBFCM data through over-the-air (OTA) methods:

	Option A1a: Data reporting via OEM, using OEM OTA capability	Option A1b: Data reporting via OEM, using eCall hardware connectivity	Option A2a: Data reporting direct to EC/EEA, using OEM OTA capability	Option A2b: Data reporting direct to EC/EEA, using eCall hardware connectivity
✓	<ul style="list-style-type: none"> Data transmission costs are very low 			
	<ul style="list-style-type: none"> There is an existing standard (ExVe) for third-party access to vehicle data via an OEM server 		<ul style="list-style-type: none"> Alleviates concerns around independence and reliability of the data Only one data transmission required (compared to two via OEM) 	
	<ul style="list-style-type: none"> Most new LDVs will have OTA capability via an OEM system, from 2021 	<ul style="list-style-type: none"> All new types of LDVs have eCall supporting hardware from 2018 OTA connectivity is enabled over vehicle lifetime 	<ul style="list-style-type: none"> Most new LDVs will have OTA capability via an OEM system, from 2021 	<ul style="list-style-type: none"> All new type approved LDVs have eCall supporting hardware from 2018 OTA connectivity is enabled over vehicle lifetime
i	<ul style="list-style-type: none"> Software/hardware updates required for most vehicles, although these are not considered technically challenging or expensive 			
	<ul style="list-style-type: none"> The effort required to transmit data OTA will vary between OEMs depending on what systems are already in place 		<ul style="list-style-type: none"> System required to allow OEMs to check/review raw data for their fleets 	
		<ul style="list-style-type: none"> eCall cellular contracts would need to be reviewed, if same SIM card is used 	<ul style="list-style-type: none"> Standards would need to be reviewed and defined in implementing legislation The effort required to transmit data OTA will vary between OEMs depending on what systems are already in place 	<ul style="list-style-type: none"> eCall cellular contracts would need to be reviewed, if same SIM card is used
✗	<ul style="list-style-type: none"> Technical malfunction or cellular dead zone may prevent OTA transmission 			
	<ul style="list-style-type: none"> Concern over potential bias for data transmission via OEM Lead times to update in-vehicle systems may limit timely implementation 		<ul style="list-style-type: none"> No industry wide standard yet for third-party direct access to in-vehicle data Lead times to update in-vehicle systems and develop standard may limit timely implementation 	
		<ul style="list-style-type: none"> eCall standards may need updating to enable transmission of OBFCM data Guidance for OEMs needed on how eCall hardware can be used 	<ul style="list-style-type: none"> OEM OTA systems not designed to transmit data to third party - longer lead times required to update vehicle system 	<ul style="list-style-type: none"> eCall standards may need updating to enable transmission of OBFCM data Guidance for OEMs needed on how eCall hardware can be used

Options relating to the collection of OBFCM data through periodic technical inspections:

	Option B1: Data reporting via PTI, EU-wide mandate	Option B2: Data reporting via PTI, optional at EU level, MS mandate	Option C4: Ad hoc sampling of EU vehicles using OTA / PTI
✓	• Data collected without role of OEMs alleviates concerns around independence and reliability of the data		
	• Low-cost and straightforward to implement: low additional effort from PTI technicians if part of legal requirement		• Potential to reduce the financial and administrative burden of data collection from EU vehicle fleet using targeted sampling rather than widespread data collection (using same techniques as identified in Options A and B)
	• Fuel consumption information would be collected for an entire year's fleet after initial grace period, as all vehicles are subject to a PTI at least every two years. • OBFCM data from HDVs could be collected annually from year of registration	• No additional legislation at EU level. • Member States can choose to collect information in the best way for them.	
i	• PTI schedules vary between Member States: vehicles of the same age would be reported in different years depending on the MS.		
	• Legal mandate at EU level	• Legal mandate set by those MS that choose to do so	• No legal mandate for data collection – voluntary / incentive based scheme • Not all vehicles would be targeted for data collection
✗	• For LDVs, no PTIs within 3 to 4 year period after first registration and therefore no fuel consumption could be collected (this is often where the most fuel is consumed (per annum) in a vehicle's lifetime). • More actors would be required in the process of collecting the data from PTIs compared to collecting data OTA		
	• Legislative requirement at EU level to be developed	• Restrictions in certain MSs regarding ability to save data/information other than that mandated by law	
		• Sample of EU fleet – data likely to be collected for only a limited number of Member States, leading to concerns regarding representativeness	• Sample of fleet collected voluntarily, leading to concerns regarding representativeness and feasibility of the sample. • Voluntary action on the part of OEMs (OTA) and PTI authorities (PTI), potentially leading to bias. • Increased effort and costs for PTI technicians to extract the data if not part of mandated system

Other options relating to the collection of OBFCM data through ad-hoc sampling:

	Option C1: Data reporting via OEM vehicle servicing	Option C2: Data reporting via In Service Conformity checks	Option C3: Ad hoc sampling of selected fleets (information provided by fleet managers)
✓	<ul style="list-style-type: none"> Potential to address gap in absence of PTI data in first- or second-year following vehicle registration via OEM servicing (Option B). Proportion of vehicles being returned to OEM/franchised dealership unknown, but likely to be high due to requirements of obligatory free two-year unlimited mileage warranty. 	<ul style="list-style-type: none"> OEMs required to perform In-Service Conformity (ISC) tests on a sample of vehicles following vehicle's first registration – could be used as an option to take read-outs from selected vehicles on real world emissions 	<ul style="list-style-type: none"> Data is regularly collected by fleet managers (particularly HDV) and therefore feasibility is high. Samples potentially much larger than option C2. Less dependence on OEMs to collate/supply data.
i	<ul style="list-style-type: none"> Those performing servicing will potentially need to upgrade OBD scan tools, and significant lead time may be required to achieve this. Additional costs that OEMs would incur would need to be passed onto the consumer. 		<ul style="list-style-type: none"> Commission responsible for determining sampling frequency, sample size, segmentations and geographic location etc. Data collection to be standardised across fleets / manufacturers to ensure appropriate calculations of fuel consumption. Voluntary data collection, with requests made to fleet managers.
✗	<ul style="list-style-type: none"> Low uptake amongst OEMs and consumers could be expected as not mandatory. It is not always the case that the entity undertaking the PTI and vehicle servicing is the same – for these entities additional reporting mechanisms would need to be in place. 	<ul style="list-style-type: none"> Sample sizes for ISC represent a very small proportion of the vehicle fleet and would therefore not be useful for understanding the fleet-wide real world fuel consumption rates. 	<ul style="list-style-type: none"> Significant concern regarding usefulness, representativeness of selected vehicles and how they have been used – particularly for LDVs.

The following subsections summarise the key points of each of the options considered.

Over-the-air data collection

Option A relates to an obligation on vehicle manufacturers to support the collection of the real-world fuel consumption data using over-the-air (OTA) connectivity. Two versions of Option A were explored:

- **A1** - the reporting of data to the Commission/EEA via the OEM.
- **A2** - the direct transfer of data to the Commission/EEA.

For each of A1 and A2 options, two OTA systems were considered for data transmission: **(a)** Using OEM independent OTA system, and **(b)** using the OTA connectivity provided by 112 eCall hardware. It has been assumed that for this option, supporting legislation would need to be developed to require action by OEMs. Therefore, a sub-option without supporting legislation has not been considered.

The conclusions from the analysis are:

- **Gathering real-world fuel consumption data from vehicles over-the-air (OTA) using vehicles' existing OTA connectivity to send the data via vehicle manufacturers (Option A1) appears to be a technically feasible and effective option.**
- **There are a number of existing methods and market ready standards that can be used by the Commission to access the OBFCM data once the data are collected by the OEM.** These include the Extended Vehicle ISO standards (LDV & HDV), the Fleet Management System (FMS) technical standards (HDV), and the use of neutral servers.
- Transmitting data from a vehicle first to the OEM makes use of the OEM's existing obligation to the vehicle owner/purchaser as a data controller.
- The majority (90%) of **LDVs** are expected to have OTA capability (outside of eCall) by 2021 with no significant bias towards particular vehicle segments. **For HDVs**, the OBFCM parameters currently defined are more commonly transmitted by HDV OTA services, although a smaller proportion of HDVs are expected to be enabled with OEM OTA systems compared to LDVs.
- **Investments would be needed by OEMs to enable this option to proceed.** HDV and LDV OEMs have already developed the associated security protocols and backend databases/servers for communicating with their vehicles and storing data, respectively; these existing systems could be used and to a small degree extended. However, not all the OBFCM parameters that must be collected and reported are currently, or planned to be, transmitted by all OEMs. Therefore, updates would also need to be made to the in-vehicle system to allow them to be sent over-the-air. These updates are considered to be mostly a straightforward process. As the data record size is small and the transmission would be annual, the expected data transmission costs are low and should be able to be subsumed into existing OTA cellular data contracts.
- **For transmitting the OBFCM data from LDVs, it is also possible to utilise the connectivity provided by the SIM card hardware that supports 112 eCall in vehicles.** All new light duty vehicle types from 2018 have eCall hardware fitted. The record size and frequency of the OBFCM data transmission is also expected to be within the limits set for 112 eCall, and so could be incorporated into exclusive eCall data contracts. For HDV, an eCall system is not expected sooner than 2024.
- **With all the OTA options for LDVs and HDVs, there is a small risk of failure in transmitting data from vehicles.** Failures may occur in cases where the vehicle has no mobile data coverage; there is a technical malfunction that prevents OTA or corrupts the data; or SIM cards become outdated if the currently used 2G/3G networks are retired. By allowing the annual data

transmission at any time of the year from the vehicle instead of at a fixed date, a more comprehensive vehicle coverage would be possible.

- **The option of direct transmission of OBFCM data from vehicles over-the-air to the Commission or EEA (Option A2)** alleviates concerns around the reliability of the data collected by OEMs and the risk of data manipulation. While there already are some third-party services accessing in-vehicle data, there is not yet a defined use-case or industry-wide solution/standard for such data transmission. This option would incur significant investment to update the OEM OTA systems and standards already in place. This option is not in-line with the Extended Vehicle standard (ISO 20077), which has been suggested as a solution for new use-cases of vehicle data access. The Extended Vehicle concept aims to limit the number of parties that have direct access to vehicle data, in order to maintain the security of connected vehicles. This option (A2) could build on the standardised eCall OTA system, which also provides an example of vehicle data transmitted to a party aside from the OEM.
- **Few actors would be required in the process of collecting data OTA.** For collecting data OTA, tens of vehicle manufacturers and the European Commission or EEA would be involved.

Periodic technical inspection data collection

Option B proposes collecting fuel consumption information stored in the vehicle during vehicles' periodic technical inspections. The required information would be read out by an OBD scan tool, passed to the relevant authority in each Member State for collation and subsequently passed to the European Commission on an annual basis. The sub-options considered are: **Option B1**- the collecting of VIN and OBFCM data would be legally required by EU law when a vehicle is brought in for its periodic technical inspection; **Option B2**: there would be no EU level requirement for the collection of VIN and OBFCM data during PTIs, but the EU would encourage Member States to set up their own legal requirements or voluntary approach to collect the data.

The conclusions from the analysis are:

- **Under Option B1, collecting data on real-world fuel consumption from vehicles would be required as part of the existing periodic technical inspections.** The obligation would lie with Member State authorities to collate data from the PTI stations and pass on to the Commission or EEA.
- **For heavy-duty vehicles, this is considered a highly appropriate option** as these vehicles' PTIs are required annually from first registration.
- **For light duty vehicles, there is a key gap in the PTI option as cars and vans do not have their first PTI until three or four years after initial vehicle registration (varying by Member State).** This means that information on the real-world vehicle fuel consumption would only become available 3 to 4 years after first registration. This is a significant time lag considering that in this portion of a vehicle life the largest annual distances are typically recorded.
- **Under Option B1, the additional effort required to gather the data on top of the existing PTI routines is expected to be minimal.** The procedure would be facilitated by the on-board diagnostic (OBD) scan tools that would be used to download the data from the vehicle. Efforts may be needed to ensure that the (independent) technical services involved in PTI have access to state-of-the-art scan tools and software.
- **The option to request Member States to voluntarily collect the real-world fuel consumption data during the period technical inspections (Option B2) is expected to lead to only some limited collection of data.**
- **Many actors would be required in the process of collecting the data through periodic technical inspections.** For the PTI option, thousands of PTI tool manufacturers and test centres, the Member State competent authorities, and the Commission would be involved.

Ad hoc sampling options

Four sub-options were considered for Option C (ad-hoc sampling):

- C1: Ad hoc sampling during vehicle servicing by OEMs (complementary);
- C2: Ad hoc sampling via other vehicle emission verification activities (complementary);
- C3: Ad hoc sampling of selected fleets (information provided by fleet managers); and
- C4: Ad hoc sampling of EU vehicles using OTA /PTI.

The findings of these options were:

Ad hoc sampling options

- **Ad hoc sampling via OEM vehicle servicing (Option C1) is a possible means to collect data from LDVs and HDVs during their first 1 to 2 years of operation.** Although servicing of vehicles is not a legal requirement, it is undertaken regularly during the first few years following first registration, particularly to ensure that the OEM minimum two-year warranty (legal requirement) remains valid. This could complement Option B (PTI) for light duty vehicles to address the gap prior to the first PTI. However, requiring this to occur through legislation would be challenging, as not all vehicles are presented by their owners to the OEM's authorised service centres (either choosing to take their vehicles elsewhere or omitting the service). Furthermore, OEMs have indicated that any additional costs that the OEMs would incur for carrying out these data acquisitions would need to be passed on to the consumer; and if the option was not mandatory, then very low take-up among consumers would be expected.
- **Using other vehicle emission verification activities, such as In-Service Conformity checks (Option C2), seems not to be appropriate for gathering the OBFCM data, as the sample sizes are too small.**
- **The ad hoc sampling of selected vehicle fleets (Option C3), could be considered as an alternative or be complementary to Options A1/2 (OTA) and B1 (PTI).** As data is regularly collated by fleet managers (particularly for HDV), the feasibility of data collection is high. However, there are issues relating to the representativeness of the selected sample and the potential differences in the use of fleet vehicles compared to the EU vehicle fleet as a whole. This is the case for LDV fleets in particular, such as taxis, rental vehicles and company cars, where fuel costs to the user are likely to differ which is likely to impact on how the vehicle is driven. This raises concerns regarding the suitability. Ad hoc sampling of HDV fleets, such as logistics companies, are likely to be more representative of the wider EU HDV vehicle fleet due to similar commercial usage.
- The collection of OBFCM data from a voluntarily elected sample of vehicles either via OTA or when presented to PTI is an option for sampling the fleet data (**Option C4**). As vehicle owners can decline to volunteer, there is uncertainty in the take-up rates (participation levels) of the data collection exercise and data collection would be on a smaller scale than Options A or B. This may undermine the usefulness of the exercise if insufficient data are gathered to be sufficiently representative.

Key data gaps and suggestions for further research

The following topics were identified as gaps for further research:

- On the number of PTI testing stations that are likely to need to purchase a new OBD scan tool (rather than being able to upgrade the software on the existing tool).
- Costs for LDV and HDV OEMs to make the changes necessary to allow real world fuel consumption data to be transmitted OTA from the vehicles.

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Appendices

Appendix A: Findings from literature review

A.1 Over-the-air (OTA) technology for Option A

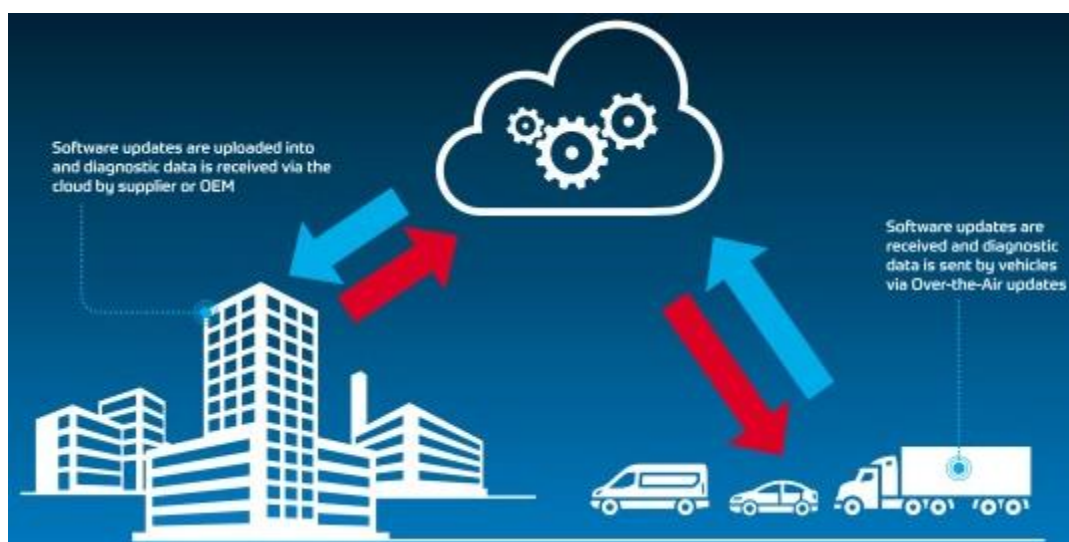
A.1.1 Definition of OTA

Over-the-air (OTA) refers to the transmission and reception of information/data within a wireless internet communication system (Figure A-1). In the automotive industry, OTA is used to describe the remote two-way data connection between vehicles and vehicle manufacturer or supplier, via a cloud platform. The main method of OTA connectivity in Europe is through cellular, although wireless and satellite connectivity is also possible. The connection can be delivered through an embedded modem in the vehicle, or by using the driver's smartphone.

OTA is used for several different applications:

- Remote vehicle updates of software and firmware by vehicle manufacturer
- Transmission of vehicle diagnostics data for service alerts, in-service conformity checks, or customer-centric products
- Monitoring of the vehicle for use by insurance companies and fleet operators
- Enabling a vehicle to communicate safety, mobility or environment-related information with its surroundings for Cooperative Intelligent Transport Systems (C-ITS) and vehicle automation
- Contacting emergency services in case of accidents (e.g. eCall). See Box 2 below.

Figure A-1: Over-the-air updates (Source: Adapted from ZF press release: ZF, 2018)



Box 2: eCall

eCall is an in-vehicle service that automatically dials Europe's single emergency number 112 in the event of a serious road accident and communicates the time and vehicle's location to the emergency services. This uses a SIM card in the vehicle that is only utilised for this service. This system is dedicated to emergency use only and is not to be considered as a platform for additional transmission of data OTA such as fuel consumption.

The applications that are most relevant to OTA transmission of data pertinent to this study are vehicle diagnostics and telematics that can both involve the monitoring and reporting of vehicle performance data. The method of monitoring a vehicle is known as telematics and is often used by insurance companies and fleet operators. The Open Telematics Platform (OTP) is an open and non-discriminatory platform for telematics applications in vehicles available since 2001, with an OBD-II (on-board device) interface (McCarthy et al., 2017). The OTP backend manages the process and ensures authorised and secure access to the vehicle operating data. The OTP adapter and OTP API can read vehicle operating data via the OBD interface and transmit the data to cloud systems. The telematics control unit (TCU) is a gateway to vehicle information and usually controls the exchange of data. It is connected to both the vehicles wireless link and the OBD (McCarthy et al., 2017).

A.1.2 OTA Status and vehicle connectivity trends

OTA connectivity is increasingly becoming an essential automotive feature that facilitates a number of applications, as listed in the section above. Cellular is the most common form of vehicle OTA connectivity and would be the most appropriate technology in relation to transmitting OBFCM data under Option A of this study.

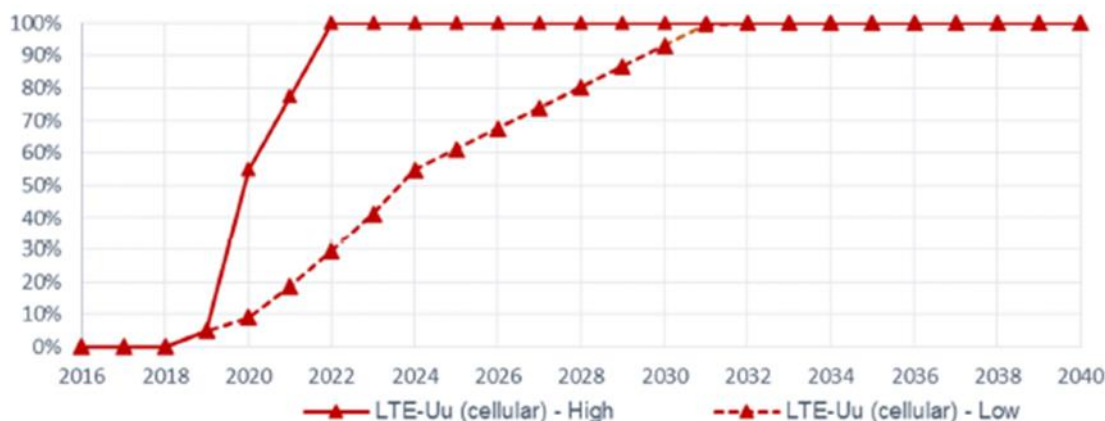
LTE is the 4G wireless communications standard that operates in the traditional mobile broadband spectrum and would be essential for enabling OTA cellular connectivity. A number of OEM's already offer vehicles with embedded LTE connectivity capability⁴². The emergence of 5G from 2020 will further broaden the cellular communication mix and support the deployment of OTA and connected vehicles.

A recently published study for the 5G Automotive Association (5GAA) entitled: "Safety of Life" includes modelled LTE penetration in new vehicles over the time frame 2016 - 2040, with a low and high penetration scenario, as shown in Figure A-2 (5GAA, 2018). The penetration assumptions were based on several industry data sources that indicated 55% of new vehicles world-wide would be equipped with the capability for cellular connectivity in 2020. A market outlook report expects the share of connected vehicles in Europe's total vehicle parc to increase from around 17% in 2018 to 50% in 2025 and 73% in 2030 (PwC Strategy & Digital Auto Report, 2018).

A key theme that will be explored with vehicle manufacturers is the share of vehicles that will have cellular OTA capabilities and importantly, to what extent connectivity will be paid for by the OEM or rely upon a subscription by the driver. This may be affected by the roll-out of OTA updates in vehicles, that could influence whether the vehicle has a permanent network subscription. Tesla was the first car manufacturer to send out OTA updates for safety critical systems such as braking and cruise control, and other manufactures are starting to follow Tesla's lead – Ford and GM have both announced plans to offer OTA software updates by 2020, while the I-PACE is the first Jaguar model to offer software updates.

⁴² <https://www.bmw.co.uk/bmw-ownership/connecteddrive/connectivity-technologies>, <https://www.ford.co.uk/shop/research/technology/connectivity/fordpass-connectivity>, <https://www.mercedes-benz.com/en/mercedes-me/connectivity/>

Figure A-2: Modelled penetration rates for LTE (cellular) capability in new vehicles (5GAA, 2018). This penetration can be interpreted as the maximum potential use of OTA connectivity in vehicles to transmit OBFCM data – maximum because having the technology capability in the vehicles doesn't mean that owners will provide the consent to using the technology.



From a regulatory point of view, the European Commission EU has acknowledged the need to, and committed to provide, support through appropriate regulation and policy, including on cybersecurity and data protection (EC COM(2018)283). The Commission recognises that vehicle connectivity is a key enabling technology for connected and autonomous vehicles, which are predicted to deliver improvements in congestion, pollution, and road safety.

A.1.3 OTA transmission of heavy-duty vehicle data

Operators of heavy duty on- and off-road vehicle fleets have been collecting telematic data for many years. Accessing real time and historic vehicle information, including location and vehicle operation parameters, allows fleet operators to optimise vehicle performance, plan servicing and improve security.

Major truck and bus manufacturers have agreed to give 3rd parties (e.g. haulage and logistics companies) access to vehicle data via the Fleet Management System (FMS) common interface, which has been designed as an open standard. This allows haulage and logistics companies with a mixed fleet of vehicles to use a single fleet management system. Development of the FMS-standard is managed by “Heavy Truck Electronic Interface Group”, under ACEA. The manufacturers involved are listed in Table A-1:

Table A-1: Heavy duty vehicle manufacturers involved in the FMS-standard

Vehicle Manufacturer	Bus	Truck
Daimler	✓ (EvoBus GmbH)	✓
MAN	✓ (MAN Truck & Bus AG)	✓ (MAN Truck & Bus AG)
Scania	✓ (Scania CV AB)	✓ (Scania CV AB)
Volvo	✓ (Volvo Bus Corporation)	✓ (Volvo Trucks)
CNH	✓ (CNH IrisBus)	✓ (CNH IVECO)
VDL	✓ (VDL Bus International B.V.)	X
Renault	X	✓ (Renault Trucks)
DAF	X	✓ (DAF Trucks)

The following safety protocols are defined:

- Application layer – SAE J1939/71
- Data link layer – SAE J1939/21
- Physical layer – ISO 11898-2 High-speed CAN, 250 kbit/s bus speed

A secure and legal solution for the remote download of data from the digital tachograph has also been defined (rFMS v2.1, 2017). Using the remote Fleet Management System (rFMS), it is possible to retrieve vehicle information and positions from the OEM server(s), via an application programme interface (API) over http. Under the 'vehicle status' resource, the following relevant parameters are a mandatory standard service parameter provided by the API and can be obtained:

- Vehicle identification number (VIN)
- Total fuel the vehicle has used during its lifetime (millilitres)
- Accumulated distance travelled during its operation (metres)

The full vehicle weight (kg) is an optional parameter. Each OEM can decide whether or not they want to implement this information in the API.

A.1.4 OTA transmission of data within non-road mobile machinery

JCB also have a telematics & machine fleet monitoring system known as LiveLink, which allows OTA transmission of data via a cellular digital network to and from LiveLink terminals. It has been a standard since 2013 and is used on over 160,000 JCB machines. In 2018, the new JCB LiveLink Control Tower system was also introduced, enabling fleet owners to import fleet data from any telematics system compliant with the Association of Equipment Management Professionals (AEMP) Telematics standard V1.2. Livelink allows owner-operator and fleet operators to remotely monitor and manage their machines, accessing collected information via the web, email or mobile phone. Users can select specific performance parameters and time periods to view data for. Fuel consumption can be collected from machines with electronic engine management system (EEMS).

A.1.5 OTA costs

The costs of OTA data transmission can be divided into on- and off-board vehicle hardware and software installation/update/maintenance costs, as well as the cellular network charges from data transmission. Software and hardware costs have not been identified in the literature and are a topic for discussion with stakeholders, especially OEMs. The findings on this will be reported on in the draft final report.

The annual cost of cellular data transmission for the entire EU vehicle fleet⁴³ not just new registrations has been estimated to the nearest thousand as €14,000. This takes the 2019 EU wholesale data transmission cap of €4.50 / Gb⁴⁴ and the assumption that there will be one transmission per year of a 10.5 kB⁴⁵ comma separated variable (CSV) data file. In practise, the value will be lower as data will not be transmitted from the whole vehicle fleet and it likely that the data transmission would be included within the existing network subscription. Costs related to the hardware and systems to send and receive the data would be additional. This topic will be explored further with stakeholders.

⁴³ LDV and HDV - estimated as 300 million

⁴⁴ https://europa.eu/youreurope/citizens/consumers/internet-telecoms/mobile-roaming-costs/index_en.htm

⁴⁵ Average size of CSV file generated from two CARB example vehicle diagnostics records for OTA transmission, available at <https://www.arb.ca.gov/regact/2018/hdobjd18/appd.pdf>

A.2 International regulations and examples of vehicle data monitoring and recording

A.2.1 Relevant regulatory examples outside EU

California, US

The California Air Resources Board (CARB) regulate emissions related parameters that must be tracked and reported in all vehicles registered in California as part of their 'On-Board Diagnostics (OBD) Program'. Regulations were introduced for light- and medium-duty vehicles in 1994 (OBD II) and expanded to heavy-duty vehicles in 2010 (HD OBD).

In 2016, broad amendments to the OBD II regulation were approved and included a requirement to collect and report new data stream parameters from 2019, which can be used to monitor and assess vehicles' fuel consumption (see Box 3 below) at the vehicle level without aggregation (not required to be OTA). Table A-2 presents differences in the data requirements between the OBD II regulation and the EU OBFCM data requirements.

As well as measuring fuel consumption itself, additional parameters have been requested to be monitored to support the interpretation of these values. For example, positive kinetic energy is a good indicator of driving style. Data will be accessed physically through the diagnostics port from drivers who participate voluntarily. It is clear that this example is very relevant to this study and so several topics will be explored with CARB in future correspondence, as outlined below.

Table A-2: Data that is required to be available to be monitored according to each regulation, that is not required in the other

CARB OBD II	EU WLTP 2nd amendment
Non-plug-in hybrid electric vehicles	
Total engine run time	Engine fuel rate
Total engine idle run time	Vehicle fuel rate
Total positive kinetic energy	Vehicle speed
Total engine output energy	
Total propulsion system active time	
Total idle propulsion system active time	
Total city propulsion system active time	
Plug-in hybrid electric vehicles	
Total grid energy consumed in charge depleting operation with engine off	
Total grid energy consumed in charge depleting operation with engine	
Total grid energy into the battery	
Vehicles equipped with active off-cycle credit technologies	
Active Off-Cycle Credit Technology #n	

Box 3: Vehicle Operation Tracking Requirements in OBD II regulation⁴⁶:

(6.3) For 30 percent of 2019, 60 percent of 2020, and 100 percent of 2021 and subsequent model year vehicles with gasoline, diesel, or alternate-fuelled engines, manufacturers shall implement software algorithms to individually track and report in a standardized format the following:

- (6.3.1) Total engine run time
- (6.3.2) Total engine idle run time
- (6.3.3) Total distance travelled**
- (6.3.4) Total fuel consumed**
- (6.3.5) Total positive kinetic energy
- (6.3.6) Total engine output energy
- (6.3.7) Total propulsion system active time
- (6.3.8) Total idle propulsion system active time
- (6.3.9) Total city propulsion system active time

(6.4) For 25 percent of 2019, 50 percent of 2020, and 100 percent of 2021 and subsequent model year plug-in hybrid electric vehicles, manufacturers shall implement software algorithms to individually track and report in a standardized format the following:

- (6.4.1) Total distance travelled in charge depleting operation with engine off**
- (6.4.2) Total distance travelled in charge depleting operation with engine running**
- (6.4.3) Total distance travelled in driver-selectable charge increasing operation**
- (6.4.4) Total fuel consumed in charge depleting operation**
- (6.4.5) Total fuel consumed in driver-selectable charge increasing operation**
- (6.4.6) Total grid energy consumed in charge depleting operation with engine off
- (6.4.7) Total grid energy consumed in charge depleting operation with engine running
- (6.4.8) Total grid energy into the battery

(6.5) For 30 percent of 2019, 60 percent of 2020, and 100 percent of 2021 and OAL-approved: July 25, 2016 subsequent model year vehicles equipped with active off-cycle credit technologies, manufacturers shall submit a plan for Executive Officer approval in accordance with (g)(6.8) to implement software algorithms to individually track and report in a standardized format the following:

- (6.5.1) Active Off-Cycle Credit Technology #1;
- (6.5.2) Active Off-Cycle Credit Technology #2; and so on up to
- (6.5.3) Active Off-Cycle Credit Technology #n.

In 2018, proposed amendments to HD OBD Regulation (1971.1)⁴⁷ and OBD II Regulation (1968.2)⁴⁸ stipulate requirements for OTA reporting of certain tracked data in the case of reprogramming, from 2022:

“the manufacturer shall collect all lifetime data stored in the vehicle pursuant to these sections using the over-air-network prior to their erasure.”

A supporting document outlines the data reporting procedures for OTA reprogrammed vehicles and engines⁴⁹. Manufacturers must collect and submit the data to CARB within 60 days of the release of the software over the air (SOTA). A comma separated variable (CSV) file should be posted to the vehicle manufacturers space on CARB's document management system using a filename based on the certification engine family or test group name and the date of the OTA release.

⁴⁶ Approved Final Regulation Orders for the OBD II (25.07/2016), at: https://www.arb.ca.gov/msprog/obdprog/section1968_2_clean2016.pdf

⁴⁷ Proposed regulation order for HD OBD regulation section 1971.1 (2018), available at: <https://www.arb.ca.gov/regact/2018/hdobd18/appa.pdf>

⁴⁸ Proposed regulation order for OBD II regulation section 1968.2 (2018), available at: <https://www.arb.ca.gov/regact/2018/hdobd18/appc.pdf>

⁴⁹ Data Record Reporting Procedures for Over-the-Air Reprogrammed Vehicles and Engines (2018), available at: <https://www.arb.ca.gov/regact/2018/hdobd18/appd.pdf>

Data requirements

- Some of the data fields are computed from single data parameters
- Some of the data fields are ratios of typically two data parameters
 - parameters are to be divided on an individual vehicle basis before the average and standard deviation are calculated
- All averages and standard deviations shall be unweighted
- All parameters shall be scaled [as percentages] as specified in the relevant industry standard (i.e., SAE J1979 or SAE J1939).
- Data record shall be submitted in a separate CSV file
- Header for the CSV file must exactly match the template

Selected Template info

- Family field (identifier) may be Test Group, Engine Family Name, or Vehicle Family Name
- Number of vehicle records included in the aggregate record
- Distance travelled (GHGDT-SD, lifetime average, floating point)
- Vehicle fuel consumption (GHGDT-AVE, lifetime average, floating point)

Within HD OBD Regulation (1971.1), the tracked data that must be reported OTA includes NOx emission tracking data for diesel engines and a number of parameters for all engine types. Under OBD II Regulation (1968.2), OTA data reporting requirements only covers NOx emission tracking data for medium-duty vehicles with diesel engines. The values collected for both heavy- and medium-duty engines shall conform to the standardised format specified in SAE J1979. SAE J1979 is equivalent to ISO 15031-5, which is the ISO regulation for data reporting requirements of On-Board Diagnostic (OBD) in Europe and the standard that OBFCM parameters must be calculated and scaled according to Commission Regulation (EU) 2018/1832.

The full list of tracked data that must be reported OTA pursuant to HD OBD Regulation (1971.1) and OBD II Regulation (1968.2) is in Box 4.

Further assessment of whether there are gaps in the ISO standard that would need to be addressed for the reporting of data as envisaged for WLTP 2nd amendment will be looked at for the next report.

Box 4: Data that must be reported OTA pursuant to HD OBD Regulation (1971.1) and OBD II Regulation (1968.2)

For 2022 and subsequent model year heavy duty engines, the following parameters shall be tracked and reported (HD OBD Regulation (1971.1)):

- (5.4.1) **Vehicle fuel consumption;**
- (5.4.2) Engine fuel consumption;
- (5.4.3) Engine idle fuel consumption;
- (5.4.4) Engine PTO fuel consumption;
- (5.4.5) **Distance travelled;**
- (5.4.6) Distance travelled while engine WHR technology is active;
- (5.4.7) EOE;
- (5.4.8) WHR output energy;
- (5.4.9) Positive kinetic energy (PKE);
- (5.4.10) Engine run time;
- (5.4.11) Idle run time;
- (5.4.12) Urban speed run time (vehicle speed >1mph, <40mph);
- (5.4.13) PTO run time;
- (5.4.14) WHR technology run time;
- (5.4.15) For non-hybrid vehicles, stop/start technology run time;
- (5.4.16) Automatic engine shutdown technology activation count;
- (5.4.17) Active technology #1 run time;
- (5.4.18) Active technology #2 run time; and so on up to
- (5.4.19) Active technology #n run time;
- (5.4.20) Distance travelled while active technology #1 is active;
- (5.4.21) Distance travelled while active technology #2 is active; and so on up to
- (5.4.22) Distance travelled while active technology #n is active

Parameters for hybrid vehicles:

- (5.5.1) Propulsion system active run time;
- (5.5.2) Idle propulsion system active run time;
- (5.5.3) Urban propulsion system active run time.

Parameters for plug-in hybrid electric vehicles:

- (5.6.1) Total distance travelled in charge depleting operation with engine off;
- (5.6.2) Total distance travelled in charge depleting operation with engine running;
- (5.6.3) Total distance travelled in driver-selectable charge increasing operation;
- (5.6.4) Total fuel consumed in charge depleting operation;
- (5.6.5) Total fuel consumed in driver-selectable charge increasing operation;
- (5.6.6) Total grid energy consumed in charge depleting operation with engine off;
- (5.6.7) Total grid energy consumed in charge depleting operation with engine running;
- (5.6.8) Total grid energy into the battery.

The parameters listed above shall be stored in three categories:

- Active 100 array
- Stores 100 array
- Lifetime array

As part of NOx emission tracking requirements, for 2022 and subsequent model year medium-duty vehicles equipped with diesel engines, the following parameters shall be tracked and reported (OBD II Regulation (1968.2)):

- (A) NOx mass – engine out (g);
- (B) NOx mass – tailpipe (g);
- (C) Engine output energy (kWh);
- (D) **Distance travelled (km);**
- (E) Engine run time (hours);
- (F) **Vehicle fuel consumption (litres).**

The parameters listed above shall be stored in four categories:

- Active 100 array
- Stores 100 array
- Lifetime array
- Lifetime Engine Activity Array

The proposals that CARB have made around the OTA transmission of emissions related parameters, are particularly relevant to Option A this study. Consequentially, we would like to explore in greater detail with CARB, the proposal that they have made. This would include at least the following questions:

China

In 2016, China released their new emission standard for light-duty vehicles (known as China 6), and in 2018 they released the final rule on the emission standard for heavy-duty vehicles (known as China VI). Whereas previous standards closely followed EU emissions standards, China 6 and VI also incorporate best practises from US emission regulations.

China 6 will take effect from 2020 and amongst other features, it requires the shift from NEDC to WLTP and specifies enhanced OBD provisions that are based on the CARB OBD II regulation. However, there are no requirements for OTA reporting of collected vehicle data.

The requirements of China VI will be implemented over two phases, as presented in Table A-3 and include a requirement for vehicles to be equipped with a remote emission monitoring terminal and transmit data to the monitoring centre of the regulatory agency throughout its life. Required data that must be reported at least every 10 seconds, includes engine fuel rate and the VIN.

Table A-3: Requirements for each stage of China VI

Standard stage	Requirements	Vehicle type	Implementation time
Stage 6a	Remote OBD hardware in place	Gas vehicle	1 July 2019
		Urban vehicles	1 July 2020
		All vehicles	1 July 2021
Stage 6b	OBD III – remote transmission	Gas vehicle	1 January 2021
		All vehicles	1 July 2023

China VI refers to the following GB (Guobiao, or “National Standard”) standards and their normative references and the security policy of this standard states that data stored and transmitted by the vehicle terminal should be encrypted. The public key cryptographic SM2 algorithm or the RSA algorithm can be used.

A.2.2 Examples of monitoring and reporting real world fuel consumption data (with relevance for Option C)

OBD data logger approach

In 2013, the International Council on Clean Transportation (ICCT) commissioned two pilot studies to investigate the logistical and technical challenges and requirements for a nationwide instrumentation study of vehicle fuel consumption. TÜV NORD Mobilität GmbH & CO conducted a pilot study in Europe, while Eastern Research Group, Inc. carried out an equivalent study in the United States. Since 2013, Canada have also been recording fuel consumption for light vehicles⁵⁰ (among other parameters) in the Canadian Vehicle Use Study (CVUS).

Both examples use data loggers to determine fuel consumption, and while this method of data collection is out of scope, the sampling and data reporting methodologies are relevant and are discussed in more detail in Section A.1.

⁵⁰ cars, minivans, SUVs and trucks with a gross vehicle weight (GVW) of less than 4.5 metric tons

Existing EU Databases

Around Europe, there are many initiatives that collect fuel consumption information. The data in these sources can be from manual vehicle user submissions, fuel cards that log fuelling events, and data from on-road tests conducted by auto magazines and car clubs⁵¹.

One example is 'Travelcard Nederland BV', which gathers fuel consumption data from business car fleets when fuel is paid for by the employer. At each fuelling event, the amount and type of fuel, an odometer reading, and the date and time are recorded. The odometer reading is manually entered by drivers and so the dataset can contain errors and missing records. Since 2008, the Netherlands Organisation for applied scientific research (TNO) has been monitoring the real-world fuel consumption of passenger cars in the Netherlands based on fuelling data obtained from Travelcard Nederland BV (Ligterink & Smokers, 2016).

By combining data from consecutive fuelling events, the distance driven between two fuelling events is deduced. Fuel consumption can then be calculated by dividing the amount of tanked fuel by the distance the vehicle has travelled. The registration database from the Dutch vehicle authority (RDW) is used to ascertain the type approval fuel consumption and CO₂ values and various other technical characteristics for each vehicle.

Another initiative is www.spritmonitor.de, a German website where car owners can log vehicle activity, including fuelling events and distance travelled. The data can be used by drivers to monitor their fuel economy and vehicle-related costs, as well as compare fuel efficiency of other vehicles.

The quantity and quality of data collected in many of these initiatives is such that they can be used in scientific studies. The ICCT 'From Laboratory to Road' international study analysed 13 EU data sources from seven Member States, which represented data from about one million vehicles (see Table A-4). The sampling and data reporting methodologies used in these examples is explored further in Section A.1.

Table A-4: Summary of EU fuel consumption data sources. Adapted from the 'From Laboratory to Road' EU report (Tietge et al., 2016)

Member state	Source	Data type
Germany	Spritmonitor.de	User-submitted
	LeasePlan	Fuel card system
	AUTO BILD	Test route
	Auto motor und sport	Test route
United Kingdom	Allstar card	Fuel card system
	Honestjohn.co.uk	User-submitted
	Emissions Analytics	Test route (PEMS)
Netherlands	Travelcard	Fuel card system
	Cleaner Car Contracts	Various data types
France	Fiches-auto.fr	User-submitted
Spain	Km77.com	Test route
Sweden	auto motor & sport	Test route
Switzerland	Touring Club Switzerland	Test route

⁵¹ Fuel consumption is typically measured before and after test drives. Portable Emissions Measurement Systems (PEMS) may also be used.

A.3 Sampling considerations for Option C

A sample-based approach to surveying a statistical population can be an effective way to ensure a representative sample can be collected without incurring the larger costs and effort of a census-based approach.

There are a number of statistical considerations that should be made:

- Options for sampling approaches - stratified vs random
- Specification of the aims and objectives
 - E.g. Determining the average fuel efficiency (l/100km) of LDVs and HDVs in Europe to monitor the deviation of the real in-use fuel consumption from the TA values.
- Characteristics to be investigated
 - E.g. Distance travelled (km, lifetime) and fuel consumed (litres, lifetime).
- The sample size, which depends upon population size, the desired confidence level and confidence interval.
 - The confidence level and interval determine the accuracy of sample results
- The variability of the data
- The risk of bias in sampling

Other (non-statistical) considerations include:

- Recruitment methodology
- Project cost

Pilot studies in North America (Eastern Research Group, 2013) and Europe (TUV Nord Mobilität, 2013) were commissioned by the international council on clean transportation (ICCT) to identify, and begin to address, the logistical and technical challenges of determining the real-world fuel consumption of vehicle fleets. Canada has actively been recording fuel consumption for light vehicles (among other parameters) through the Canadian Vehicle Use Study (CVUS) (Transport Canada, 2014). Furthermore, across Europe there are many initiatives that collect fuel consumption information through vehicle user submissions, fuel cards that log fuelling events, and data from on-road tests conducted by auto magazines and car clubs. These examples have been discussed below to examine their sample methodologies and what considerations have been made in more detail.

A.3.1 Statistical vehicle sample considerations

The key consideration for a robust sample is its 'representativeness' and while this will increase as the sample size increases, an effective selection methodology can also achieve a representative sample, while managing the costs that scale according to the sample size. If participation in a sampling task is voluntary, an **unrestricted random sample** is not suitable due to the potential bias arising from the self-selecting sample. Both ICCT pilot studies concluded that **stratified sampling**⁵² is the most suitable option, because of a good understanding of the vehicle fleet. In the CVUS, the Canadian vehicle fleet is also stratified. A stratified sampling approach would be the most suitable approach for this study due to the large population size and a good understanding of the vehicle fleet exists.

Before a sample can be selected, the statistical population must be delimited. In this study, the statistical population would be the set of registered LDVs & HDVs in Europe covered under EC Regulation 2018/1832. The representativeness of this population relative to the EU vehicle fleet should be considered.

⁵² In stratified sampling, the statistical population is divided into separate groups, called strata. A sample is then drawn from each group.

In stratified sampling, the population is then split into sub-groups or 'strata'. On or more parameters that are related to the investigated characteristic should be used to determine this stratification, such that there is homogeneity within layers and inhomogeneity between layers. The US pilot study selected 'propulsion system' and 'Fuel economy labels (highway & urban)' as the stratification variables, while the CVUS stratifies the vehicle fleet by 'type of vehicle' and 'vehicle age'.

The sample size will depend on whether a proportional or disproportional sampling approach is taken. In proportional distribution sampling, the sample allocation to a stratum is proportional to the square root of the population in the stratum. If a disproportional sampling approach is chosen, equal sample sizes can be selected from each layer, which may increase the time and costs required for the investigation but ensures reliable conclusions can be drawn.

The US ICCT pilot study recommended a **minimum sample size of 200 vehicles for the main study**. This would result in uncertainty of about +/- 11% on the standard deviation of arbitrary distributions of values of fuel economy influencing coefficients. This uncertainty would be reduced to +/- 8% with a 400-vehicle sample. In the CVUS, a quarterly stratified proportionally distributed sample of 6000 vehicles is taken with a non-response of around 1,000. The final sample has a global confidence level of 95% and a 3% confidence interval, and for the majority of groups the quality of data reaches a satisfactory level on an annual basis.

In the EU ICCT pilot study, estimations on sample size based on different assumptions indicated that:

- ~200 vehicle sample is suitable for analysing individual influences of the real vehicle fuel consumption.
- ~500 vehicles sample allows for a more detailed analysis of the deviation of the real fuel consumption from the type approval values.
- ~1,000+ vehicle sample is suitable if the objective is a detailed investigation with an analysis of the FC behaviour for popular vehicle models.

From the aforementioned studies, stratified sampling can be considered the most appropriate sampling methodology, but before it can be determined whether proportional or disproportional sampling of the sample strata is more suitable, the stratification parameters must be selected. If the stratification results in relatively small strata, these layers may be under sampled in a 'proportional sampling' approach, and disproportional sampling may be more appropriate. Furthermore, the calculation of the sample size depends on the agreed goals of the investigation and the assumptions about the calculation parameters.

Further work to investigate sampling considerations and develop a methodology will be undertaken in the study and reported on in the next study report.

A.3.2 Vehicle Recruitment Methodology

Another consideration in the sampling methodology is the identification and recruitment of vehicles to collect data from. There are a number of possible sources for collecting vehicle data from LDVs:

- Household survey
- Vehicle registration database
- Vehicle rental suppliers
- Vehicle clubs
- Company cars
- Light commercial vehicle fleets

Of these, 'household survey' and 'vehicle registration database' would not be suitable options for this study's context. While the CVUS revised the Canadian Vehicle Survey (CVS) to act as its recruitment tool, there is no equivalent ongoing EU-wide household survey and conducting such a survey would be

an expensive and time-consuming undertaking. Many Member States do however carry out national travel surveys (NTS), although these are not standardised and have different data collection methodologies (Christensen & Vazquez, 2013). Coordinating the use of multiple national travel surveys to recruit an EU vehicle sample also seems unsuitable. Furthermore, while the US ICCT pilot study considered the use of the vehicle registration database to source participants, there is a considerable data privacy challenge with this option and it would require corporation from each MS to access their national vehicle database

Passenger cars

Across the EU there are many vehicle clubs, whose members include private drivers and fleet operators. These clubs have a range of objectives including road assistance and vehicle services, industry regulation, environmental protection and road safety. In the EU ICCT pilot study, these clubs were considered the most promising option for securing participating vehicles, and the Fédération Internationale de l'Automobile (FIA) was identified as a global contact for different vehicle clubs. Three German vehicle Clubs were contacted in that study:

- Allgemeiner Deutscher Automobil-Club (ADAC)
- Auto Club Europe (ACE)
- Automobilclub von Deutschland (AVD)

Companies with fleets of vehicles are also likely to be interested in understanding real world fuel consumption of their vehicles and as shown in Table A-4, there are a number of business fuel card systems that already monitor vehicle consumption. In the EU ICCT pilot study, vehicle leasing suppliers were contacted but did not show interest due to marketing policy reasons.

Data in the UK shows that 9% of the UK passenger vehicle parc are company registered (DfT - vehicle licensing statistics, 2019) and in the Netherlands about 45% of new cars sold are leased vehicles (Ligterink & Smokers, 2016). On average, leased vehicles have higher annual mileages than privately owned vehicles and so **leased vehicles often will largely determine the average national real-world fuel consumption** and can be considered representative (Ligterink & Smokers, 2016). Through national fuel card system providers (Allstar Card) and leasing associations (LeaseEurope), large company and leased fleets can be identified to engage with.

Light commercial vehicles

Another promising source of participants would be light commercial vehicle fleets. As discussed in Section A.1.3, fleet operators are interested in collecting vehicle data (TÜV NORD Mobilität, 2013) and many already have remote fleet management systems to help operators manage their vehicles. Light commercial vehicle registrations are 12% of total light-duty vehicle registrations in the EU. Accordingly, the share of light commercial vehicles in the total light-duty fleet that would be required to make available fuel consumption parameters, would increase from around 1% in 2021, to 5% in 2027⁵³.

Incentives

A final consideration for recruitment is incentives. As part of the ICCT EU pilot study, a survey was carried out at TUV NORD service stations. A quarter of the 322 respondents were interested in participating in the fuel efficiency pilot study, and on average every third volunteer requires an incentive. The study suggests amounts of €80 to €100 but highlights that larger incentives up to €250 would further reduce the efforts of the participation process. The US pilot study discusses five incentive package concepts: monetary, gift cards, games on the study website, free American Automobile Association membership, and a vehicle data report. The study also noted that staggering incentives is effective at

⁵³ The year in which that Commission shall assess how the real-world emissions gap has evolved.

encouraging continued participation. The Canadian Vehicle Use Study uses a number of incentives, including a monthly \$1000 draw and a personalised driving report.

A.3.3 Project cost

Both ICCT pilot studies provided estimates for the cost of a national scale study. The total cost varied from €321,000 to €3.8 million between the studies, depending on vehicle sample size (200-800) and data logger price. Costings included preparation, data collection and data evaluation stages. The cost estimation for the EU pilot study is reproduced in Table A-5. However, costs for data logger installation logistic and data logging solutions are not applicable to the options considered in this study as the technology to collect, store and make available the data required will already be available in vehicles registered from 2021.

Table A-5: Nationwide OBD FE/CO₂ data collection cost summary (source: TÜV NORD Mobilität, 2013)

Project Step	Subject	Data Logger Unit Price	€ 120			€ 500		
		Vehicle Sample Size	200	500	1000	200	500	1000
Vehicle Sampling	Sample design		€ 30,000					
	Driver Incentives		€ 20,000	€ 50,000	€ 100,000	€ 20,000	€ 50,000	€ 100,000
Driver Maintenance	Data logger installation logistic		€ 15,000	€ 20,000	€ 25,000	€ 15,000	€ 20,000	€ 25,000
Data Logging Solution	Data logger hardware,		€ 36,000	€ 90,000	€ 180,000	€ 112,000	€ 280,000	€ 560,000
	Data logger customization		€ 75,000					
	Non-standard PIDs		€ 50,000	€ 90,000	€ 130,000	€ 50,000	€ 90,000	€ 130,000
Data Evaluation	Data collection and pre-processing		€ 75,000					
	Analysis of data and documentation		€ 20,000	€ 25,000	€ 30,000	€ 20,000	€ 25,000	€ 30,000
Total Sum [€]			€ 321,000	€ 455,000	€ 645,000	€ 397,000	€ 645,000	€ 1,025,000

Appendix B: Stakeholders consulted; interview transcripts and questionnaires

Table B-1: Summary of stakeholders consulted

Stakeholder Type	Organisation/ Member State contacted	Written response to questionnaire and/or separate questions	Telephone interview
Light duty vehicle manufacturers	BMW	Yes	Yes
	Daimler	Yes	No
	Fiat Chrysler	Yes	Yes
	Ford	Yes	Yes
	General Motors	No	No
	Honda	Yes	No
	Hyundai	Yes	Yes
	Jaguar Land Rover	No	No
	Peugeot	No	No
	Renault	Yes	Yes
	Toyota	Yes	Yes
	Volkswagen	Yes	No
	Volvo	Yes	No
Heavy duty vehicle manufacturers	DAF	Yes	No
	Daimler	No	No
	Iveco (CNH)	Yes	Yes
	MAN	No	No
	Scania	Yes	Yes
	Volvo	No	No
National Authorities:	UTAC CERAM	Yes	Yes
France	Ministère de la Transition écologique et solidaire [Ministry for the Ecological and Inclusive Transition:]		
Germany	Bundesministerium für Verkehr und digitale Infrastruktur (BMVI) [Federal Ministry for Transport and digital Infrastructure] Kraftfahrt-Bundesamt (KBA) [Federal Motor Transport Authority]	Yes	Yes
Netherlands	RDW	Yes	No
United Kingdom	Driver Vehicle and Standards Agency (DVSA)	Yes	Yes

Stakeholder Type	Organisation/ Member State contacted	Written response to questionnaire and/or separate questions	Telephone interview
Other stakeholders	International Motor Vehicle Inspection Committee (CITA)	Yes	Yes
	Member organisations of CITA:		
	Center for Vehicles of Croatia	Yes	No
	Applus+ Spain	Yes	No
	KÜS - Kraftfahrzeug-Überwachungsorganisation freiberuflicher Kfz-Sachverständiger e.V. (Germany)	Yes	No
	European Federation of Leasing Company Associations (Lease Europe)	Yes	Yes
	DHL	No	No
	UPS	No	No
	Hermes	Yes	No
	DPD	No	No
	TNT	No	No
	FEDEX	No	No
	Enterprise	No	No
	California Air Resources Board (CARB)	Yes	Yes
	European Environment Agency (EEA)	Yes	Yes
	International Council on Clean Transportation (ICCT)	Yes	No
	The Federation of German Consumer Organizations (VZBV)	Yes	No
	Transport & Environment (T&E)	Yes	No
	Alertgasoil	Yes	Yes
	British Association of Public Safety Communications Officials (BAPCO)	Yes	No

Interview transcripts and questionnaires: contained in separate confidential file.

Appendix C: WLTP 2nd amendment

In 2018, the Commission adopted Regulation (EU) 2018/1832, which amended Directive 2007/46/EC, and Regulations (EU) 692/2008 and 2017/1151 (WLTP).

It added new requirements into Regulation (EU) 2017/1151 for the type-approval regarding devices for monitoring the consumption of fuel and/or electric energy. These requirements are set out in Article 4a and Annex XXII of that Regulation, and are replicated below.

Article 4a

The manufacturer shall ensure that the following vehicles of categories M1 and N1 are equipped with a device for determining, storing and making available data on the quantity of fuel and/or electric energy used for the operation of the vehicle:

(1) pure ICE and Not-Off-Vehicle Charging Hybrid Electric vehicles (NOVC-HEVs) powered exclusively by mineral diesel, biodiesel, petrol, ethanol or any combination of these fuels;

(2) Off-Vehicle Charging Hybrid Electric Vehicles (OVC-HEVs) powered by electricity and any of the fuels mentioned in point 1.

The device for monitoring the consumption of fuel and/or electric energy shall comply with the requirements laid down in Annex XXII.

ANNEX XXII

Devices for monitoring on board the vehicle the consumption of fuel and/or electric energy

1. Introduction

This Annex sets out the definitions and requirements applicable to the devices for monitoring on board the vehicle the consumption of fuel and/or electric energy.

2. Definitions

2.1 *'On-board Fuel and/or Energy Consumption Monitoring Device'* ('OBFCM device') means any element of design, either software and/or hardware, which senses and uses vehicle, engine, fuel and/or electric energy parameters to determine and make available at least the information laid down in point 3, and store the lifetime values on board the vehicle.

2.2 *'Lifetime'* value of a certain quantity determined and stored at a time t shall be the values of this quantity accumulated since the completion of production of the vehicle until time t .

2.3 *'Engine fuel rate'* means the amount of fuel injected into the engine per unit of time. It does not include fuel injected directly into the pollution control device.

2.4 *'Vehicle fuel rate'* means the amount of fuel injected into the engine and directly into the pollution control device per unit of time. It does not include the fuel used by a fuel operated heater.

2.5 *'Total Fuel Consumed (lifetime)'* means the accumulation of the calculated amount of fuel injected into the engine and the calculated amount of fuel injected directly into the pollution control device. It does not include the fuel used by a fuel operated heater.

2.6 *'Total Distance Travelled (lifetime)'* means the accumulation of the distance travelled using the same data source that the vehicle odometer uses.

2.7 *'Grid energy'* means, for OVC-HEVs, the electric energy flowing into the battery when the vehicle is connected to an external power supply and the engine is turned off. It shall not include electrical losses between the external power source and the battery.

2.8 '*Charge sustaining operation*' means, for OVC-HEVs, the state of vehicle operation when the REESS state of charge (SOC) may fluctuate but the intent of the vehicle control system is to maintain, on average, the current state of charge.

2.9 '*Charge depleting operation*' means, for OVC-HEVs, the state of vehicle operation when the current REESS SOC is higher than the charge sustaining target SOC value and, while it may fluctuate, the intent of the vehicle control system is to deplete the SOC from a higher level down to the charge sustaining target SOC value.

2.10 '*Driver-selectable charge increasing operation*' means, for OVC-HEVs, the operating condition in which the driver has selected a mode of operation, with the intention to increase the REESS SOC.

3. Information to be determined, stored and made available

The OBFCM device shall determine at least the following parameters and store the lifetime values on board the vehicle. The parameters shall be calculated and scaled according the standards referred to in points 6.5.3.2 (a) of Paragraph 6.5.3. of Appendix 1 to Annex 11 to UN/ECE Regulation No 83, understood as set out in Point 2.8. of Appendix 1 to Annex XI to this Regulation.

3.1. *For all vehicles referred to in Article 4a, with the exception of OVC-HEVs:*

- (m) Total fuel consumed (lifetime) (litres);
- (n) total distance travelled (lifetime) (kilometres);
- (o) engine fuel rate (grams/second);
- (p) engine fuel rate (litres/hour);
- (q) vehicle fuel rate (grams/second);
- (r) vehicle speed (kilometres/hour).

3.2. *For OVC-HEVs:*

- (a) Total fuel consumed (lifetime) (litres);
- (b) total fuel consumed in charge depleting operation (lifetime) (litres);
- (c) total fuel consumed in driver-selectable charge increasing operation (lifetime) (litres);
- (d) total distance travelled (lifetime) (kilometres);
- (e) total distance travelled in charge depleting operation with engine off (lifetime) (kilometres);
- (f) total distance travelled in charge depleting operation with engine running (lifetime) (kilometres);
- (g) total distance travelled in driver-selectable charge increasing operation (lifetime) (kilometres);
- (h) engine fuel rate (grams/second);
- (i) engine fuel rate (litres/hour);
- (j) vehicle fuel rate (grams/second);
- (k) vehicle speed (kilometres/hour);
- (l) total grid energy into the battery (lifetime) (kWh).

4. Accuracy

4.1 With regard to the information specified in point 3, the manufacturer shall ensure that the OBFCM device provides the most accurate values that can be achieved by the measurement and calculation system of the engine control unit.

4.2 Notwithstanding point 4.1, the manufacturer shall ensure that the accuracy is higher than – 0,05 and lower than 0,05 calculated with three decimals using the following formula:

$$\text{Accuracy} = \frac{\text{Fuel_Consumed}_{\text{WLTP}} - \text{Fuel_Consumed}_{\text{OBFCM}}}{\text{Fuel_Consumed}_{\text{WLTP}}}$$

Where:

Fuel_Consumed_{WLTP} (litres)

is the fuel consumption determined at the first test carried out in accordance with point 1.2 of Sub-Annex 6 of Annex XXI, calculated in accordance with paragraph 6 of Sub-Annex 7 of that Annex, using emission results over the total cycle before applying corrections (output of step 2 in table A7/1 of Sub-Annex 7), multiplied by the actual distance driven and divided by 100.

Fuel_Consumed_{OBFCM} (litres)

is the fuel consumption determined for the same test using the differentials of the parameter "Total fuel consumed (lifetime)" as provided by the OBFCM device.

For OVC-HEVs the charge-sustaining Type 1 test shall be used.

4.2.1 If the accuracy requirements set out in point 4.2 are not met, the accuracy shall be recalculated for subsequent Type 1 tests performed in accordance with point 1.2 of Sub-Annex 6, in accordance with the formulae in point 4.2, using the fuel consumed determined and accumulated over all performed tests. The accuracy requirement shall be deemed to be fulfilled once the accuracy is higher than – 0,05 and lower than 0,05.

4.2.2 If the accuracy requirements set out in point 4.2.1 are not met following the subsequent tests pursuant to this point, additional tests may be performed for the purpose of determining the accuracy, however, the total number of tests shall not exceed three tests for a vehicle tested without using the interpolation method (vehicle H), and six tests for a vehicle tested using the interpolation method (three tests for vehicle H and three tests for vehicle L). The accuracy shall be recalculated for the additional subsequent Type 1 tests in accordance with the formulae in point 4.2, using the fuel consumed determined and accumulated over all performed tests. The requirement shall be deemed to be fulfilled once the accuracy is higher than – 0,05 and lower than 0,05. Where the tests have been performed only for the purpose of determining the accuracy of the OBFCM device, the results of the additional tests shall not be taken into account for any other purposes.

5. Access to the information provided by the OBFCM device

5.1 The OBFCM device shall provide for standardised and unrestricted access of the information specified in point 3, and shall conform to the standards referred to in points 6.5.3.1 (a) and 6.5.3.2 (a) of Paragraph 6.5.3. of Appendix 1 to Annex 11 to UN/ECE Regulation No 83, understood as set out in Point 2.8. of Appendix 1 to Annex XI to this Regulation.

5.2. By way of exemption from the reset conditions specified in the standards referred to in point 5.1 and notwithstanding points 5.3. and 5.4., once the vehicle has entered into service the values of the lifetime counters shall be preserved.

5.3 The values of the lifetime counters may be reset only for those vehicles for which the memory type of the engine control unit is unable to preserve data when not powered by electricity. For those vehicles the values may be reset simultaneously only in the case the battery is disconnected from the vehicle. The obligation to preserve the values of the lifetime counters shall in this case apply for new type approvals at the latest from 1 January 2022 and for new vehicles from 1 January 2023.

5.4. In the case of malfunctioning affecting the values of the lifetime counters, or replacement of the engine control unit, the counters may be reset simultaneously to ensure that the values remain fully synchronised.

Appendix D: Factors that influence real world fuel consumption

D.1 Vehicle characteristics (e.g. vehicle load and fuel type);

Vehicle load

Increasing a vehicle's load (i.e. passengers and/or cargo) can negatively influence the fuel consumption as more power is required to accelerate and the rolling resistance will increase. The impact is greater at low speed transient driving than at higher speeds, where the majority of the tractive power is used to overcome air drag and so is less vehicle load dependant. In cars, the load is typically determined by the number of passengers, or occupancy rate, and while there has not been a significant change in occupancy rate over time across the whole EU, EEA data shows that there has been some variation between Member States.

The impact of load carrying is most relevant for HDVs and the ability to calculate payload is very important for interpreting fuel consumption accurately. From discussions with HDV manufacturers as part of this study, it is clear that payload is not consistently measured across all vehicles and that there are a number of challenges to estimating payload. While the Gross Train Weight (GTW) (total mass of vehicle, including cargo and passengers) of the vehicle is often estimated onboard for use by automatic transmission and braking systems, calculating the payload requires knowledge of the kerb weight (the weight of the vehicle without occupants or cargo). This is not always known by the vehicle manufacturer and in some cases, it can be hard to define what should count as kerb weight or payload. The challenges and possible solutions to record payload are explored in more detail in Section 6.3.2.

For passenger cars, 100kg additional load will contribute about 5-7% to fuel consumption (Fontaras et al., 2017). While there is not considered to be a significant change over time, the same additional load will increase the fuel consumption of smaller cars more than larger cars. For trucks, additional load is a key consideration when interpreting the fuel consumption as there can be considerable variability. Furthermore, it may be necessary to normalise the real world fuel consumption data to reflect the payload that was considered under HDV CO₂ certification Regulation 2017/2400 being compared against. Therefore, it is more important for HDVs that payload is calculated and reported as part of real-world fuel consumption analysis.

Fuel type

Different fuels have different densities and energy contents, which will influence fuel consumption and CO₂ emissions. Aggregation that includes vehicles using different fuels, will introduce a systematic variation in fuel consumption. If there was a trend in the fleet to go, for example, from diesel to petrol vehicles, then the average fuel consumption will vary which can complicate calculating the gap. Trends in fuel use may also vary by OEM fleet and MS. For diesel fuel, the standard figure for the CO₂ emissions due to combustion is 2.639 kg CO₂ per litre for fuel, and for petrol it is 2.304 kg CO₂ per litre of fuel. Published data on passenger car real world and type-approval fuel consumption data are available in Figure 3 of TNO (2016). In 2015, their data, in litres of fuel per 100 km, are as tabulated below, with the corresponding CO₂ emissions data in the two right-hand columns.

Table D-6. Passenger car real world and type-approval fuel consumption data (adapted from Ligterink & Smokers, 2016) and the corresponding CO₂ emissions

	litres /100 km		gCO ₂ /km	
	Real-world	Type Approval ⁵⁴	Real-world	Type Approval
Diesel	5.35	4.00	141.2	105.6
Petrol	6.50	5.35	149.7	123.2

Therefore, for real-world driving the TNO data suggests that the fuel type introduces a variation of around +/- 3% in average CO₂ emissions. However, this is likely to be an underestimate if the systematic differences in vehicle types are excluded, and the comparison is for like-for-like vehicle types (because the larger, heavier passenger cars tend to be diesel fuelled, raising the overall average CO₂ emissions relative to petrol vehicles). With the increasing popularity of electric vehicles and the recent movement away from diesel, the share of fuel types in new vehicle registrations is changing and so considering this when monitoring and assessing trends in EU fleet fuel consumption is important. For example, vehicle data could be aggregated and interpreted by fuel type to account for the impact of fuel type on fuel consumption. Furthermore, Member States should know what fuels are being sold in their markets and so variation can be normalised at this aggregation level as well.

D.2 The use of auxiliary systems fitted to the vehicle;

Auxiliary systems are fitted to vehicles to improve the comfort and safety of the vehicle's occupants and are estimated to represent ~3% of a vehicle's fuel consumption (Leduc et al., 2010). The main systems include air conditioning (A/C) and heating, infotainment, power assisted steering, lights and windscreen wipers. There has been a general trend in passenger cars toward increased electricity demand for auxiliary systems as more complex infotainment and safety features are introduced.

While climate can influence the use of A/C and heating systems, it is not considered to vary significantly between Member States in Europe. However, vehicle manufactures who produce high-end vehicles may see a greater impact of the use of auxiliary systems on their fleet's average fuel consumption, compared to manufacturers of lower priced vehicles. This variability in the impact of auxiliaries on fuel consumption could be accounted for when interpreting fuel consumption per manufacturer.

D.3 Vehicle maintenance and ageing;

While tyre wear can influence the performance of a vehicle, it is difficult to assess the impact on fuel consumption, and tyre wear control is monitored as part of the PTI regime. Low tyre pressure has a much larger impact on fuel consumption due to a higher rolling resistance, which led to tyre pressure monitoring systems (TPMS) being made mandatory for all new cars in the EU from 2012. While the extent to which drivers respond to TPMS is not known, differences are not considered significant across the vehicle fleet or over time.

During a vehicle's life, distance accumulation will initially produce gradual improvements in fuel economy. However, as components wear, over time the average fuel economy of a vehicle tends to decrease (ICCT US Pilot study). Regular vehicle maintenance through routine services can effectively counter much of the decrease and so variation in vehicle servicing can result in variations in vehicle fuel consumption. As the vehicle ages and moves out of in-warranty servicing, maintenance typically reduces, compounding the impact of vehicle ageing on fuel consumption. Furthermore, as vehicle technology continues to advance, sensors and vehicle connectivity enable better monitoring of the car

⁵⁴ Average CO₂ certification values (measured using Directive 2007/46/EC, as amended, and the NEDC) and reported in this 2016 TNO publication.

and vehicle maintenance prompts to the driver. We may therefore see improvements in vehicle servicing across the EU fleet over time. Finally, difference between segments and manufacturers may exist, with more care given to more expensive and technologically advanced vehicles compared to cheaper models.

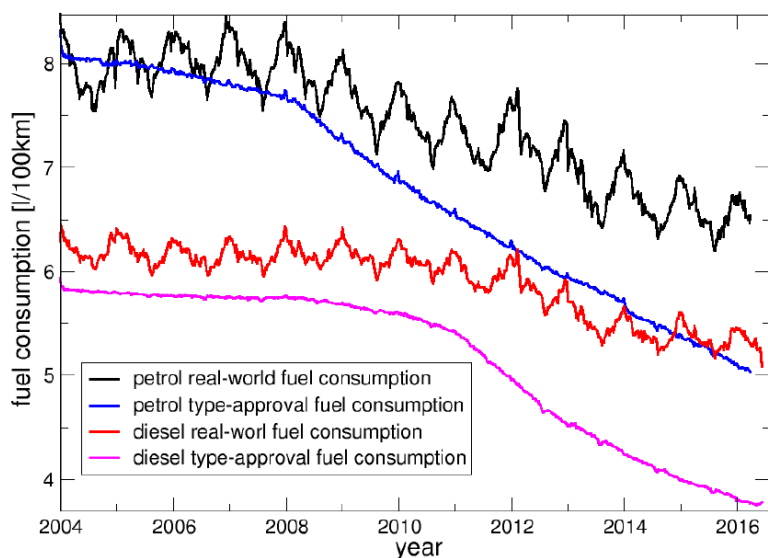
Consideration of the impact of mileage on fuel consumption can be made through the model year character of the VIN, or by considering the vehicle's accumulated lifetime distance travelled parameter. This will also partly account for low tyre pressure, as accumulated mileage is one of the causes of pressure loss. Difference between segments and manufacturers can also be accounted for by interpreting fuel consumption at these aggregation levels. It is difficult to quantify fleet level improvements in servicing over time, but it is important to be aware of nonetheless.

D.3 External factors (e.g. climate, weather, road conditions and traffic conditions)

Climate, weather and seasonality

Wind, temperature and altitude all have a significant impact on fuel consumption. Weather can influence the way a vehicle is driven, the use of auxiliary systems and tyre rolling resistance. The ambient temperature influences the fuel consumption during the vehicle's warm up phase. According to Weilenmann et al (2009), the fuel consumption of Euro 4 petrol and diesel cars at 23°C compared to 7°C, was measured as being as much as 69% lower.

However, an important component of this can be the impact of cold starting, when vehicles use more fuel than when the engine is at its normal operating temperature. The impact of cold starting is larger for petrol vehicles than for diesel vehicles. So, key parameters are the average temperature, and the **average trip length** because cold start excess emissions become less significant for longer trips. It is anticipated that the Weilenmann et al. study represents something of an extreme case. A more representative indication can be taken from the 2016 Ligterink & Smokers study. Figure 3 from this study, which gives data on passenger car real world and type-approval fuel consumption, is reproduced below. This study, published in 2016, shows how the "gap" to the average CO₂ certification value (using Directive 2007/46/EC, as amended, and measured over the NEDC, has evolved between 2004 and 2016. It is appreciated that the introduction of WLTP (Regulation (EU) 2017/1151, as amended) will reduce this gap, and that the Commission have introduced additional measures (e.g. In-service conformity testing) to further reduce the gap.

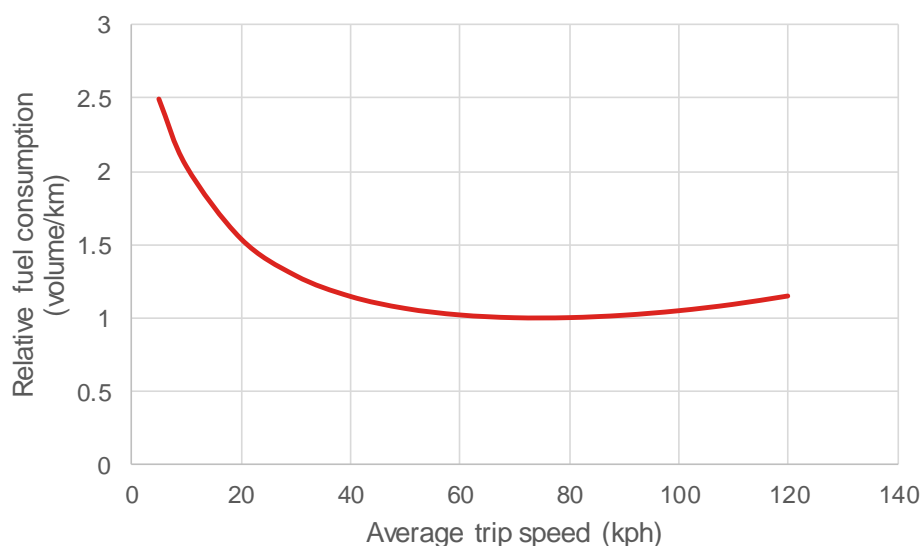
Figure D-3: Average real-world and type approval (NEDC) fuel consumption (Ligterink & Smokers, 2016)

The data clearly shows an annual variation as the seasons change, with the depth of modulation being smaller for the diesel vehicles. From analysing these data, the size of the modulation is found to be around ± 0.33 litres /100 km (or $\pm 5\%$) for petrol cars, and ± 0.2 litres /100 km (or $\pm 3.6\%$) for diesel cars. (The reasons for the variation are many and varied, and include cold starting, the use of winter/summer tyres, and variations in the use of air condition, and ambient temperatures. The causes are of interest, but the important message for this study is that real world fuel consumption varies seasonally, and that collecting average fuel consumption data over a whole year will significantly reduce this variability.)

Across Europe, temperature variations resulting in fuel consumption modulation of this magnitude can be experienced, although by collecting and analysing the data annually, the impact of seasonal variability is removed. Consistent annual climatic differences between EU countries exist, and so analysis of fuel consumption with the knowledge of the vehicle's country of registration can help to normalise the data. This information would be easily known if the data is collected and reported by Member States, but not if it is collected OTA. While the VIN will not directly tell you the country of registration, it can be used to indirectly identify where the vehicle is registered.

Road and traffic conditions

It is well documented that fuel consumption per kilometre travelled varies with average trip speed. This is the basis of the speed related emission factors, and fuel consumption data that forms the foundation of the Tier 3 (most sophisticated) inventory compilation methodology. Using the standard data from the 2018 EEA hot emissions factor database gives a typical relationship as shown in Figure D-4.

Figure D-4: Speed related fuel consumption of Euro 6 medium PFI passenger cars (EEA, 2018)

From this curve, for an urban road where the average speed is 20 km/h, if congestion reduces the speed to 10 km/h or 5 km/h, fuel consumption increases by 32% and 62% respectively. For stationary traffic this may partially be offset by fitting a stop-start engine management system to the vehicle. Vehicle speed is a major source of fuel consumption variability and on average, there may be differences between vehicle manufacturers and Member States. A representative equation correction factor that normalises the fuel efficiency to a specified speed would allow for mitigation or some correction towards speed variability between manufacturers and Member States. The average vehicle speed would need to be collected, or the accumulation of engine run time could be collected and used to calculate average speed. These parameters are not planned to be collected.

D.4 Driver factors

The way a vehicle is driven has a significant impact on fuel consumption and is typically characterised by average speeds, acceleration and choice of gears. One study that quantified the impact of economical versus aggressive driving styles focussed on the potential efficacy of gear shift indicators (GSI). Three vehicles (VW Golf, BMW Mini and Ford Transit van) were driven round four track circuits (city, handling, hills and high speed) by three different drivers driving economically and aggressively (AEA, 2010). (They were driving either as they wished or attempting to follow the GSI indications.) When not following the GSI, driving aggressively led to a 50% increase in fuel consumption for the city, handling, and hills circuits, and around a 23% increase for the high-speed circuit.

Consequently, on average aggressive driving was found to increase fuel consumption by around 50%. If this is compounded with the impact of average speed/congestion, then driving aggressively in congested traffic at an average of 5 km/h relative to economically in a city at an average of 20 km/h, increases fuel consumption by 143%, more than doubling it.

Vehicle manufacturers have highlighted that drivers of 'sportier' vehicle are more likely to drive aggressively than less sporty vehicles. Real world fuel consumption interpretation by vehicle segment can go some way to accounting for this variability. Studies show that driver behaviour has not changed significantly over time, and so any real-world consumption trends observed shouldn't be attributed to driver behaviour.

D.5 Trip characteristics (e.g. vehicle speed, trip length, grade)

Average vehicle speed

EMEP/EEA speed related emission factors (EEA, 2018) show that fuel consumption is closely linked with vehicle speed. This variability is repeated in the FCA data (Figure 5-1). However, it is noted that average speed is not a parameter that is planned to be collected for vehicles. It can lead to variations in fuel consumption of a factor of 2.5.

Average trip length

Average trip length impacts fuel consumption principally through the relative contribution of cold starting excess emissions. The EMEP/EEA guidebook (EEA, 2018) suggests the average trip length for passenger cars is around 10 km. For vehicles with high annual (and hence daily) mileages, the cold start excess emissions will be relatively small. However, for vehicles that undertake on average two to four 7 km journeys each day, i.e. around 7,500 km per year, the cold start excess emissions (as estimated using the EMEP/EEA guidebook methodology) would be around 50% of the hot running emissions for a petrol vehicle. The average trip length for HDVs is longer and so there is a smaller relative contribution of cold start excess emissions (Paffumi, 2018)

A consideration of the Member State a vehicle is registered in may help to normalise the data somewhat, but variation between Member States is not considered significant.

Gradients

Inventory methodologies indicate that for passenger cars, impacts of gradients are not generally that significant because the excess fuel used to go up a gradient is off-set by reduced fuel when going down the gradient. Consequently, in the EMEP/EEA guidebook of emission factors (EEA, 2018), no differences are given for different gradients for light duty vehicles.

For HDVs this is generally not the case. For gradients of 3% or greater, when descending, the vehicle applies braking, which does not compensate for the greater fuel consumption required when ascending. The EMEP/EEA guidebook of emission factors (EEA, 2018) gives the following fuel consumption data for a fully laden Euro V (fitted with selective catalytic reduction) articulated lorry: for a level road 11.22 MJ/km; going down a 6% slope approximately 0 MJ/km and going up a 6% slope 64.70 MJ/km. So, the average of going up and down this slope is 32.35 MJ/km, 288% of the fuel consumption of a vehicle travelling on a level road. Differences in average trip slope is not expected between HDV manufacturers, although differences between Member States may exist, which can be accounted for by aggregating at the Member State level.

D.6 Other

Possible aggregation at a vehicle family level has been discussed earlier. If this option for data aggregation were selected, a valid question is: "What is the CO₂ certification value for the interpolation family against which the real fuel economy is compared?" One possible option is the mean between WLTP(L) and WLTP(H), the interpolation limits for the family. However this may not be the optimum choice.

A better choice might be a registration weighted average. Vehicle CO₂ families have an upper and lower CO₂ boundary within which vehicles are distributed. The weighted average depends on the vehicle's individual values within the family and will often be skewed toward one end of the interpolation range. For example, it may be the lower bound if the upper bound represents a vehicle with auxiliary systems/physical modifications that increase its fuel consumption, but consumer choice leads to fewer vehicles being sold with these characteristics compared to vehicles with fuel consumption performance at the lower bound. Vehicle distributions within the family vary year-to-year and so a vehicle's CO₂ family weighted average will change over time. The vehicle's model year can be identified from the 10th

character of the VIN and consideration of this would allow the correct average weighted family CO₂ value to be compared against, accounting for variation over time.



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